SIXTEENTH ANNUAL REPORT

OF THE

Quebec Society for the Protection of Plants

1923-1924

Supplement to the report of the Minister of Agriculture

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QUEBEC

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To the Honourable J. E. Caron, M.P.P.,

Minister of Agriculture,

Quebec.

Sir :—

I have the honour to present herewith the sixteenth Annual Report of the Quebec Society for the Protection of Plants, containing the proceedings of the winter meeting of the Society, which was held at Macdonald College, Ste. Anne de Bellevue, Que., on Wednesday, April 23rd, 1924.

Included are the papers that were read, and the reports of the officers of the Society.

I have the honour to be,

Sir,

Your obedient servant,

E. MELVILLE DUPORTE,

Secretary-Treasurer.

Macdonald College, Quebec.

QUEBEC SOCIETY FOR THE PROTECTION OF PLANTS.

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Swaine, Dr. J. M.	Entomological Branch, Dept. of Agric., Ottawa
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Tessier, G.	Forest Service, Quebec.
Vanterpool, T. C.	Macdonald College.
Victorin, Rev. Bro.	University of Montreal, Montreal.
Willey, Dr. A.	58 Metcalfe St., Montreal.
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Rev. Father Superior Dom Pacome Gaboury, La Trappe, Que.
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Rev. Father Superior, Ste. Anne de la Pocatière.
J. C. Chapais, D.Sc., St-Denis-en-bas, Que.
A. Gibson, Esq., Dominion Entomologist, Ottawa.
Hon. Minister of Crown Lands and Forests, Quebec.

FINANCIAL STATEMENT

QUEBEC SOCIETY FOR THE PROTECTION OF PLANTS.

Sixteenth Annual Meeting.

RECEIPTS

Balance forward	$183.73
Government Grant	250.00
Interest	13.20
	$446.93

EXPENDITURES

Printing, Postage	17.33
Lecturers at Ann. Meeting	91.16
General expenses of Meeting	15.00
Secretary	50.00
Delegate to Royal Society	12.00
Delegates to Entomological Society	11.00
Delegates to Phytopathological Society	37.25
Grant for Experiments on Onion Maggot Control	38.70
Balance in hand on May 10th, 1924	174.49
	$446.93

E. M. DUPORTE,
Auditor.

W. LOCHHEAD,
President.

B. T. DICKSON,
Sec. Treasurer.

NOTE.—Two small accounts outstanding at this date.

ANNUAL MEETING

The Sixtee th Annual Meeting of the Quebec Society for the Protectoni of Plants wa3 held in the Biology Building on Wednesday, April 23rd, 1924. There was a very satisfactory attendance of members, some forty being present at the afternoon session and over fifty at the evening meeting. Special speakers included Prof. Dalbis of the University of Montreal, Prof. Howitt of the Ontario Agricultural College and Dr. Brittain of the Truro Agricultural College. I rof. Dalbis gave an extremely able and interesting illustrated lecture on "Fabre, his life and work" which unfortunately is not included among the printed papers in the report.

Principal F. C. Harrison, D. Sc., F.R.S.C. gave a very hearty welcome on behalf of himself and Macdonald College to the invited speakers and to the members. He pointed out the value of bringing experts in to the Society from other centres of scientific endeavor, both from the point of view of hearing them officially and of discussing with them informally the many difficult problems which present themselves in the study of plants in health and disease. He took the opportunity of reminding his hearers of the grave setback given to such work by non-continuance of the Federal Grant.

The business meeting opened at 11 a.m. with Rev. Father Leopold in the chair—the President, Prof. Wm. Lochhead being in England.

The minutes of the last meeting were approved.

The report of the Secretary-Treasurer was read and accepted.

The following officers were then elected for the year 1924-25:—

President:—Prof. W. Lochhead, Macdonald College.
Vice-President:—Rev. Father Leopold, La Trappe.
Secretary-treasurer:—Dr. E. Melville DuPorte, Macdonald College.
Directors:—C. E. Petch, Esq., Hemmingford, Que.
Prof. Father Louis Marie, La Trappe.
A. F. Winn, Esq., Montreal.
Prof. Bro. Victorin, Univ. of Montreal.
G. Maheux, Esq., Provincial Entomologist, Que.
Dr. B. T. Dickson, Macdonald College.
G. Bouchard, M.P., Ste-Anne de la Pocatière.
Dr. A. T. Charron, St-Hyacinthe, Que.
Auditor:—J. G. Coulson, Esq., Macdonald College.
Delegate to the Royal Society of Canada:—Dr. Dickson.
Delegates to the Ontario Entomological Society:—Prof. W. Lochhead. and Rev. Father Leopold.
Delegates to the Canadian Branch of the American Phytopathological Society:—Dr. B. T. Dickson, Rev. Father Leopold Mr. O. Caron and Mr. J. G. Coulson.
Delegate to the British Association Meeting in Toronto, August, 1924:—Dr. E. M. DuPorte.

It was resolved that the Society so far as funds are available, continue to help in aiding investigations concerning economic diseases caused by insects, fungi, or bacteria.

A REVIEW OF OUR KNOWLEDGE CONCERNING IMMUNITY AND RESISTANCE IN PLANTS

J. E. Howitt, Professor of Botany, Ontario Agricultural College, Guelph, Ont.

Immunity and resistance in plants is a subject of great possibilities to the Plant Pathologist. It appears to offer a solution for some of our most out-standing and important pathological problems, such as the prevention of loss from grain rusts; the control of citrus canker in the south; the re-establishment of the American chestnut in the United States; the production of beans free from anthracnose, mosaic and root rot; and the prevention of soil diseases, such as cabbage yellows, flax wilt, cotton wilt, tobacco root rot, and stem and root rot of canning peas. It offers to the man of scientific inclination a host of intricate and fascinating problems in the fields of bio-chemistry, plant physiology, genetics and ecology. It is by no means a new subject. We find it stated in "Diseases of Field and Garden Crops" by Worthington Smith, published in 1884, that "Experiments are now being carried out under the auspices of the Royal Agricultural Society to improve qualities of the potato, especially in its power of resisting attacks of the potato disease, by crossing S. tuberosum L. with its allies, and among them S. Maglia, Sch." (1).

Let us very briefly note some of the more important accomplishments in the production of disease resistant plants. W. A. Orton by selection, succeeded in producing a number of varieties of cotton resistant to wilt (Necomospora vasinfectum) and by crossing the citron with the water-melon he produced a commercial water-melon resistant to wilt caused by a soil Fusarium (2). It is interesting to know that this water-melon did not prove to be resistant when grown on the Pacific coast. Bolley by selection has produced strains of flax resistant to wilt (Fusarium lini). J. B. Norton by hybridization has furnished asparagus growers with varieties resistant to rust, such as Martha and Mary Washington (3). L. R. Jones has supplied Wisconsin cabbage growers with commercial varieties of cabbages resistant to yellows, caused by the fungus Fusarium conglutinans. Johnson has by hybridization and selection produced strains of White Burley tobacco showing marked resistance to root rot caused by Thielavia basicola. The immunity of many commercial varieties of potatoes to canker or wart disease has been demonstrated in Germany, Holland, England and America, and affords a striking instance of practical control by substitution of immune for susceptible varieties.

Time will not permit of any extended review of the progress that has been made with the wheat rust problem in the production of resistant varieties.

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1. Smith Worthington G. Diseases of field & Garden Crops.
2. Smith, Erwin F. Royal Hort. Soc. Rept. 1907.
3. Norton J. B. Washington Asparagus, U. S. Sept. of Agr. (Office Cotton Truck & Forage Crop Disease Cir. 7, 1919.

It may be noted however, that the chief advance so far has been in the solving of many of the fundamental problems in genetics, and in the isolating of the numerous biologic strains which constitute Puccinia graminis tritici. One cannot refer to this important work without mentioning the names of Eriksson Biffin, Stakman, Pole Evans and Melchers. One of the most promising reports, in that it offers scientific evidence as to the possibility of producing varieties of common wheat resistant to a large number of biologic forms of stem rust, is that of Aamodt (1), in the Journal of Agricultural Science on the "Inheritance of growth habit and resistance to stem rust in a cross between two varieties of common wheat. He reports "That the resistance and susceptibility of the host to several different forms of rust, are inherited as a single genetic factor."

The work that has been done in the breeding and selection of beans resistant to anthracnose illustrates the complications of such a problem due to the existence of different biologic strains of the fungus. In 1911 M. F. Barrus, of Cornell, proved that there were at least two distinct binologic strain of Colletotrichum lindemuthianum in New York State which he designated as alpha and beta. Nearly all the varieties of beans tested by Barrus were susceptible to one or the other of these strains. A few however, were resistant to both, among these were Wells Red Kidney and White Imperial (2). From these two varieties Burkeholder, McCrostie and Reddick developed several other commercial varieties of beans resistant to anthracnose in New York. Burkeholder later showed the existence in New York of a third biologic strain which he called the gamma strain, and demonstrated that neither Wells Red Kedney, nor White Imperial were resistant to it. In fact Wells Red Kidney, which hitherto had been considered the most resistant variety of all to the anthracnose fungus was especially susceptible to this third biologic strain (3). J. B. Leach (1923) reports that in Minnesota there are at least eight distinct biologic strains of Colletotrichum lindemuthianum (4). The presence of these distinct biologic strains in different localities complicates the problem of the breeding of anthracnose resistant varieties. It would appear that the biologic strains in any locality must first be isolated and varieties bred and selected in relation to them. Probably the most practical progress that has been made in the production of disease free beans is the work of Reddick and Stewart in proving that the robust bean is immune to the mosaic disease. Burkeholder states that the growing of pea beans in New York State had been practically discontinued due to the mosaic disease, but as a result of the intro-

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1. Aamodt, Olaf. S. Jour. Agr. Res. 24; 457-469, 1923.
2. Barns, M. F. Phytopathology 1: 190-195, 1911.
3. Burkcholder, W. H. Phytopathology 13 316-323, 1923.
4. Leach, J. G. Minnesota Agr. Expt. Sta. Tech. Bul. 14, Mch 1923.

duction of the robust, the acreage of the pea bean is now as large as formerly (1).

Other promising results with disease resistant plants are those of Coons of Michigan, from his work on seed production of Golden Self-blanching celery resistant to Yellows, (Fusarium sp.) (2) and those obtained by Jagger, who selected eight varieties of lettuce apparently immune to mildew (Bremia lactucae Reg.) in both California and Florida. These varieties were however, all of European origin and not suited to American conditions, so they were hybridized with the popular variety Los Angeles Market or New York, which is sold under the name of Iceberg lettuce. This variety is very susceptible to mildew. The results in the second generation indicate that immunity is inherited as a simple Mendelian dominant character, so that it is expected that hybridization and selection will give immune strains of New York and other popular varieties of lettuce.

Let us next consider the nature of immunity and resistance and review the scientific evidence available concerning the causal factors. In any discussion of this kind, one must keep in mind that there is immunity, resistance, apparent resistance or apparent immunity and tolerance, and there is a danger of confusion them.

True immunity or complete resistance to disease is rare among plants, but we have such examples of it in the varieties of potatoes immune to potato wart or canker; buri cotton in India immune to wilt, caused by Fusarium.

Resistance, as the term is used by plant pathologists, is in reality relative immunity or relative resistance to infection. Plants which are said to be resistant to a particular parasite are affected by it but the attack is slight as compared with that on the less resistant kinds. Resistance is much more common than immunity. It is recorded as occurring among the various varieties of nearly all our cultivated plants. True immunity and resistance being relative terms no attempt will be made to deal with them as separate phenomena in this paper.

Apparent immunity or resistance, which is in reality escape from disease is quite distinct from, and should not be confused with, true immunity or true resistance. Plants may escape disease for various reasons, such as climate and seasonal conditions unsuitable to the parasite; absence or scarcity of insect carriers of the inoculum; absence from the locality of the particular biologic strain of the pathogene capable of infecting the variety supposed to be resistant. In Ontario many of our early potatoes escape late blight and

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1. Burkeholder, W. H. Phytopothology 14, 1-8, ja. 1924.
2. Coons, G. H. Miltose, Ray. Phytopathology, 13, 24 Ja. 1923 (Abstract).
3. Jagger Ivan E. Phytopathology 14, 122, F. 1914 (Abstract).

rot because they have completed their development before the season of the year that climatic conditions become such as to allow for the spread and development of the pathogene. Early varieties of oats frequently escape rust, apparently for the same reason. On the College Farm at Guelph, during the past two years, no bunt has developed in spring wheat, even when the seed was covered with smut sportes before seeding. This is an example of escape and not of resistance, as the variety of wheat sown was known to be subject to bunt in Western Canada. The escape was probably due to the high temperatures just after seeding, which were unfavorable to the germination of the spores of the bunt fungus. In Northern Ontario leaf roll of potatoes does not appear to spread. A variety grown on the same farm for years often remains apparently immune to leaf roll, whicle the same variety when grown in Southern Ontario for two or three years becomes badly affected with it. The apparent immunity to leaf roll of potatoes in Northern Ontario, is, in the opinion of the writer, probably an instance of escape due to the comparative scarcity of aphids and other insect carriers of the inoculum of leaf roll. Examples of escape due to the absence of certain biologic strains of the pathogene are seen in the cases of varieties of wheat, which, when grown in certain localities, appear to be highly resistant to stem rust, but which, when grown in other places, prove to be susceptible. Another illustration of escape of this nature is Wells Red Kidney bean, which appeared to be resistant to the bean anthracnose fungus in New York, until the discovery of the gamma strain of the fungus by Burkeholder.

Tolerance of disease is again distinct from immunity and resistance. It may be due to strong and vigorous growth. Tolerance is seen in the case of the round-leaved mallow (Malva rotundifolia) attacked by Puccinia malvacearum. Frequently mallow plants are seen with the lower surface of the leaves covered with telia, but the plants never appear to be seriously injured by the fungus. On the other hand, hollyhock leaves affected by the same fungus usually wither and die before the normal time. Too many of our weeds appear to be tolerant of parasitic fungi. Tolerance is sometimes due to the fact that the tissues of the host are able to react so as to lessen the injury. Butler cites as an example of the type of tolerance, tea affected by red rust (Cephaleuros mycoidea). The chief damage of the pea plant by this organism is to the young twigs not protected by bark. The parasite works from the surface towards the wood, it cannot penetrate cork. The tissues of the twigs respond to the attack of the parasite by laying down corky tissues under the point of infection, thus preventing further penetration and injury by the parasite! It is possible that we have another example of such tolerance among varieties of potatoes infected by Spongospora subterranea.

The causes for apparent resistance or immunity to disease and tolerance are comparatively easily explained. But when we consider the causes for

true immunity and resistance, we find ourselves involved in a maize of anatomical, physiological, bio-chemical and ecological evidence and theories which have been offered, some to explain specific cases of resistance and other to explain the problem in general. Before entering into a discussion of these it is well to have clearly in our minds the fact brought out by Butler in his paper on "Immunity and Disease in Plants" (1) that what we commonly think of as infection consists of two stages; the first being the entrance of the parasite into the tissues of the plant, and the second the establishment of parasitic relationship with the host. Some fungi, such as the rusts, enter many plants from which they cannot obtain nourishment, and consequently perish because they are not able to accomplish the second stage of infection.

After considering these two stages of infection one realizes that immunity and resistance may be due to morphological and anatomical characters of the plant which prevent the first stage of infection, or entrance of the parasite into the tissues; or to bio-chemical properties or anatomical characters of the tissues of the host which prevent the second stage of infection or the establishment of parasite relation ship with the tissues of the plant.

Some students of this subject consider that immunity due to morphological and anatomical characters preventing the first stage of infection is disease escape, and confine the term immunity to those cases, due to lack of comptability of the parasite with the tissues of the plant.

Cases of immunity or resistance due to the anatomical characters of the host preventing entrance to the parasite are comparatively numerous (3). Coffee leaf disease usaully starts on the undersurface of the leaf as there are few stomata on the upper surface. Young beat leaves are practically immune to attacks by Cercospora beticola because their stomata are so small as to be incapable of opening widely enough to allow for the entrance of the germ tube of the spores of the fungus, which can only enter the host through the mature stomata (4). Certain varieties of plums are resistant to brown rot caused by Scletrotinia cinerea, beacause the stomata soon become plugged with masses of small parenchymatous cells. The toughness of the skin, the firmness of the flesh, and high fibre contents are also important characteristics which make varieties of plums resistant to brown rot. It has been found that as ripening progresses the texture of the resitant varieties remains firm, while that of the susceptible becomes softer. The stomata of Kanred wheat, which is resitant to certain strains of Puccinia graminis tritici, are said to be of such a nature as to "shut out most of the fungi"(6). In a more recent paper by Allen it is

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1. et 2. Butler, Edwin John, Immunity and disease in Plants, Agr. Jour. India 1918, (Spec. Indian Sci. Congr. No. 1028, 1918.
3. Butler, Edwin John, l.c.
4. Pool Veniss Morrel & McKay, Marion B. Jour. Agr. Res. 5, No 2, No 22, 1011-1038, 1916.
5. Valleau, W. D. Jour. Agr. Res. 5, No. 9, 365-395. N. 29, 1915.
6. Allen R. F. Jour. Agr. Res. 23:2. 131-132, 1923.

pointed out that there is a tendency in wheat to keep many of its stomata closed and it is suggested that the secretion by the appressorium renders the mechanism of the stomata inoperative and they remain closed, thus excluding the fungus. It is also pointed out that in Kanred wheat with its smaller stomata, these peculiarities of stomatal behaviour might be more effective in excluding fungi than in varieites of wheat with larger stomata (1). It has been shown that the resistance of Citrus nobilus to citrus canker is due to a broad ridge overarching the outer chamber of the stomata, which practically excludes water from them, thus preventing the entrance of the canker bacteria (2). Appel states that the resistance of some Remontant carnations to rust is due to the formation of the stomata which makes it impossible for the hyphae to penetrate (3). Neger, studying the biology of the Erysiphaceae and making cross inoculations, found that in some cases in which host plants showed resistance, that many of the penetrating haustoria become eveloped in a gummy deposit secreted by the epidermal cells, which prevents them entering the plant (4). The resistance of certain varieties of barley to rust is due to the bloom (waxy coating) on the leaves which prevents drops of water adhering to them, consequently the rust spores are unable to germinate on them. It is also recorded by Appel that the more waxy varieties of raspberries and grapes are those less damaged by Coniothyrium (5). Lutman from his investigations regarding the resistance of potato tubers to scab (Actinomyces scabies) states "that at the head of the resistant class stand the potatoes of the russet type and that thickness of skin determines resistance of tubers to scab." He also records that close texture lenticels partly buried under the skin surface and filled with small cells are also associated with the russet type of potatoes.

It is thought that the hairs on the leaves may influence resistance. Appel states that varieties of potatoes with small hairy leaves and open habit of growth dry quickly after wetting and are less liable to infection by Phytophthora infestans than other kinds. It is probable that the open habit of growth and not the abundant hairs is the chief factor with such varities! It is also asserted that "hairs also seem to save the under surface of the apple leaves from infection with the apple sacb fungus (Venturia inecqualis), while Venturia Pyrina readily attacks the smooth under-surface of the pear leaves" 7. This statement does not agree entirely with my own observations in regard to the scab on apple. I have frequently observed that most, if not all primary infection by apple scab is on the lower surface of the leaves. It is also a matter of common observation that the young fruits, while still covered with down are very susceptible to scab. It is interesting to note in this connection that

1. Allen R. F. Jour. Agri. Res. 24: 12, D. 1923.
2. McLean Forman L. & Lee. H. Atherton. Phytopath, 11: 109-114. Mar. 1921.
3. Appel, D. Science, N. S. 41, No 1065: 773-782, May 28, 1915.
4. Niger, F. W. Flora CXVI. 3, 331-335, 1923.
5. Lutman, B. F. Vir. Agr. Expt. Sta. Bul. 215, Je. 1919.
6. Appel. O. l.c.
7. Butler Edwin John, l.c.

the very hairy Common Mullein (Verbascum thapsus) is attacked by six leaf inhabiting parasitic fungi, while but three are reported as occuring on the labrous Moth Mullein (Verbascum blattaria.)

Morphological structures peculiar to varieties influence susceptibility. Varieties of pears with an open channel from calyx to core are those most susceptible to Fusarium putrefaciens, a fruit-rotting organism. Appel attributes the immunity to loose smut in wheat and barley to the closed flowers found in the resistant varieties. Fromme, calls attention to the fact that this cannot be the explanation for resistance in the case of wheat, no varieties of which have closed flowers, according to the information avaliable to him (1). It does however, explain the immunity found among varieties of barley to loose smut, as some varieties of barley undoubtedly have flowers which do not open and expose the stigmas to infection. The rare occurrence of Claviceps purpurea on what is said to be due to the brief and irregular openings of the glumes as maturity (2). It may be of interest to note that the writer's attention was this spring called to a lot of seed wheat (wild goose variety) that contained considerable ergot.

Let us next consider cases of immunity due to incompatability of the invading organism with the tissued of the plant, or in other words the failure of the organism to accomplish the second stage of infection, the establishment of parasitic relationship with the host. The prevention of this second stage of infection is, in some instances due to the anatomical characters of the host tissue, but more often to bio-chemical properties of the cells. Examples of structural characters influencing resistance have been observed in plums attacked by Sclerotinia cinerea, and potato tubers infected by Pythium debaryanum. Some varieties of plums become more liable to rot when they begin to ripen. This is due to a softening of the middle lamellae between the cells which allows the fungus to force its way through the tissues more rapidly (3). In making a physiological study of the parasitism of Pythium debaryanum on the potato tuber, Hawkins and Harvey found that the fungus secretes a toxin which kills the cells, and an enzme which breaks down the middle lamellae but does not affect to any extent the secondary thickenings. They observed that White McCorminck, a potatoe very resistant to Pythium debaryanum has a higher crude fibre contents than that of suceptible varieties. This higher fibre content they attribute to more secondary thickenings in the cell walls. Resistance to infection, they found, is apparently due to the resistance of the cell walls to mechanical puncture by the invading hyphae (4).

When we come to consider cases of immunity due to bio-chemical properties of the cells we find ourselves confronted with many complicated theories, some

1. Fromme, F.D. Phytopath. II: 507-510, D. 1921.
2. Stager, R. Mitt. naturforach, Gesellch, Bern. 1922, pp. 11-20, 1923.
3. Valleau, l.c.
4. Hawkins, Lona and Harvey, Rodney B. Jor. Agr. Res. 18, No 5, Dec. 1, 1919.

of them more speculations. All however, support the general fundamental theory that such immunity is owing "to a definite antagonistic chemical inter-action between host and parasite."

Maryatt, and later Stakman, showed that resistance of some plants to rust is due to the dying of the cells surrounding the point of infection, and thus starving the obligate parasite. This is termed super-sensitivity (1). The cause for the dying of the cells surrounding the point of infection in advance of the invasion of the parasite has not been determined, bub it would seem from the recentwork of Allen that it is bio-chemical. J. G. Leach states that in a variety of bean highly resistant to Colletotrichum lindemuthianum seldom more than one or two cells are attacked, and that all evidence seems to indicate that resistance is due to the inability of the fungus to obtain nourishment from the living protoplasm. What is the bio-chemical property of the host cells of resistant varieties of beans that makes it impossible for the invading hyphae to obtain nourishment form them? This question has not been answered

Tannin is very frequently found in vegetable cells and is, as a rule, toxic to fungi. Cook and Taubenhaus point out the fact that the beans are more susceptible to Colletotrichum lindemuthaianum during those stages of their growth when the enzyme which acts on gallic acid in the cells to form tannin is least abundant. In apples pears and persimmons, and other fruits, this enzyme is less abundant when the fruits are ripe than when they are green (3). This may explain the decreased resistance to rots observed in ripe fruits. Cook found that tannin effects the various species of Endothia very differently. E. radicalis and E. Gyrose are inhibited by it, while E. parasitica is at first retarded and later is able to feed on the tannin (4).

Acidity of the cell sap evidently plays some part in resistance to Guignardia bidwellii, and varieties of grapes containing less tartaric acid in thier celle sap have been found to show to show greater resistance to Guidnardia bidwellii than those containing higher quantities. Botrytis has been shown to be repelled by certain acids found in plant cells. The resistance of grapes to powdery mildew (Uncinula necator) has also been correlated with the acidity of the cell sap, the resistant varieties containing more tartaric acid than the less resistant kinds. Comes, an Italian investigator has drawn attention to the fact that Rieti, a variety of wheat strongly resistant to rust in Italy, has a more acid sap than that of any of the other less resistant kinds tested, and that loss of resistance in this wheat when grown in warmer localities than its native area is correlated with reduced acidity of the sap (5). Popp, in his investiga-

1. Stakman, E. C. Phytopath, 4:400. D. 1914 (Abstract).
2. Leach, l.c.
3. Cook, M. F. & Fautenhans, J.J. Deleware Agr. Erp. Sta. Bul. 98, Jy. 1912.
4. Cook, M. F. & Wilson, G. W. New Jersey, Agr. Exp. Sta. Bul. 291, 1916.
5. Butler, l.c.

tions concerning the hydrogen-ion concentration and natural immunity of plants found that injections of pathogenic bacteria cause the plants to respond with variations in the hydrogen-ion concentration. Immediately after infection the acidity decreases. At the end of the incubation period the acidity rises. If the plant is able to withstand the infection the acidity then falls back to normal. If the plant is unable to withstand the infection, hydrogen-ion concentration rises to a very high level, and then falls, usually below normal!

Other cell contents besides those already discussed appear to account for some cases of resistance. Biologic species of parasitic fungi are known to be very sensitive to the minutes differences in the albumen contents of the host plants. This may explain with some varities of plants are resistant to certain biologic strains and not to others. Walker in his researches on disease resistance to onion smudge, found that some substance (or substances) closely associated, or identical with, the yellow and red pigments found in the cells of the other scales of the resistant bulbs,was evidently the chief cause of resistance to onion smudge (2) (Colletotrichum circinans). It has been found that the leaves of certain species of oak immune to powdery mildew have a smaller soluble nitrogen content than the leaves of susceptible species (3). The paper by Lepschkin on the "Influence of Vitamines upon the development of yeasts and moulds" (4) makes one speculate as to the part that these vital substances may play in resistance in plants. This is a field of future reasearch for the bio-chemist.

Our present knowledge of immunity and resistance in plants would seem to warrant the following statements.

First.—That substantial and permanent progress has been made in the production and selection of resistant varieties of plants.

Second.—That further and more extensive studies concerning the existence of biologic straims of different parastitic fungi are required.

Third.—That our knowledge concerning the bio-chemical causes of resistance is fragmentary and disconnected.

Fourth.—That future reaserch work on this subject lies largely in the filed of bio-chemistry.

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3. Mont martini, L. Rev. Pat. Veg 9: 72-79, 1919.
4. Lepeshkin, W. Amer. Jour. Bot. 11, 169-189, March 1924

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THE DEVELOPMENT OF APPLIED ENTOMOLOGY IN CANADA

1914-1923

By Arthur Gibson, Dominion Entomologist, Ottawa.

In the period covered by this review much progress has been made in applied entomology in Canada, both in the federal and provincial services (1). In discussing the development of this branch of science, I shall first of all refer to the federal organization at Ottawa and then discuss important progress

(1) In the 45th Annual Report of the Entomological Society of Ontario, for 1914, the late Dr. Hewitt contributed an article entitled "Applied Entomology in Canada; Its Rise and Progress". This paper discussed the subject up to about the year 1914.

which has taken place in the various provinces, as a result of federal, provincial, or other activities.

Federal Organization

Since 1914, the federal entomological service has developed to a marked degree (1). At that time the permanent staff including entomologists and clerical workers, numbered 20, in addition to which a few students were employed at Ottawa, during the summer months. To-day the permanent staff numbers 58 and in addition, in 1923, 61 temporary assistants were employed; of this total, 15 comprised the clerical staff. In 1914, there was no divisional organization at Ottawa; now there are, in addition to my own administrative division, four definite divisions, namely: Division of Field Crop and Garden Insects, (R. C. Treherne, Chief in charge) (2); Division of Forest Insects, (J. M. Swaine, Associate Dominion Entomologist in charge); Division of Foreign Pests Suppression, (L. S. McLaine, Chief in charge); and Division of Systematic Entomology, (J. H. McDunnough, Chief in charge). Investigations relating to fruit insects, live stock insects, greenhouse insects and other pests, not conducted by the above divisions are under the immediate direction of the Dominion Entomologist.

Division of Field Crop and Garden Insects.

The work of the officers of this Division has had to do with the bionomics and control of such important pests as the various species of cutworms; the destructive species of grasshoppers which of late years have been particularly injurious in the Prairie Provinces; the European Corn Borer, of which the investigations relating thereto are showing much promise; the Western Wheat Stem Sawfly, which has developed to an alarming extent, particularly in Manitoba and Saskatchewan, and concerning the control of which important data have been secured; the Hessian Fly in Ontario, Manitoba and Saskatchewan, the so-called fly-free seeding dates for fall wheat being especially investigated in the former province; white grubs, from the study of which a short regular crop rotation will to a large extent prevent serious injury; alfalfa insects, including special investigations relating to the Alfalfa Thrips in southern Alberta; root maggots, studies of the control of which have demonstrated throughout Canada the value of the corrosive sublimate remedy for the Cabbage Root Maggot, and the sodium-arsenite bait combined with the sowing of culled onion sets as a trap for the Onion Maggot, etc. This Division has permanent field laboratories at Strathroy, Ont.; Treesbank, Man.; Saskatoon, Sask.; and Lethbridge, Alta., and temporary laboratories at other points.

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(1) During the eleven years of service of the late Dominion Entomologist Dr. C. Gordon Hewitt, the Dominion Entomological Service was developed from a very small division attached to the Experimental Farms Branch, to an important separate Branch of the Department of Agriculture.

(2) Obit., June 7, 1924.

Division of Forest Insects.

Officers of this Division have been engaged in investigating such important pests as the Spruce Budworm which during the last decade has ravaged spruce and balsam forests in Ontario, Quebec and New Brunswick; species of bark-beetles including the Destructive Spruce Bark beetle affecting all our species of spruce; the destructive pine bark beetles; the Douglass Fir Bark-beetle in British Columbia, and others which attack various coniferous trees; the Satin Moth, a European pest recently introduced into British Columbia, which attacks willows and poplars; the Larch Sawfly, which is increasing in eastern Canada and concerning which special life-history and parasite studies have been in progress in New Brunswick; the Fall Webworm, the Forest Tent Caterpillar, the White-marked Tussock moth, and other forest and shade tree pests which have received special study in New Brunswick, particularly with regard to their natural control by parasitic and other agencies. This Division, in addition, has established numbers of forest sample plots in Quebec, Ontario and New Brunswick, the trees in which are studied each year much valuable information being secured regarding the insects and other agencies which affect the health of the timber, and the extent to which each is injurious. The Division has permanent field laboratories at Fredericton, N. B; Aylmer, Que; Indian Head, Sask; and Vernon, B. C., and temporary laboratories in other districts.

Division of Foreign Pests Suppression.

The officers of this Division are specially charged with the administration of the Regulations of the Destructive Insect and Pest Act, in so far as insects are concerned. Previous to Sept. 1st, 1923, nursery stock entering Canada from countries other than Europe (including Great Britain) was subject to fumigation with hydrocyanic acid gas for a period of 45 minutes. Fumigation stations for this purpose were erected at St. John, N. B; St. Johns, Que; Niagara Falls and Windsor, Ont; Winnipeg, Man; North Portal, Sask; and Vancouver, B. C. In addition to fumigation, nursery stock from the States of Vermont, New Hampshire, Maine, Massachusetts, Connecticut and Rhode Island, and also from Europe and Asia, was inspected. During the ten years ending March, 1923, approximately, 20,000,000 plants were examined by federal inspectors, as a result of which such foreign pests as Gipsy Moth, Brown-tail Moth, Apple and Cherry Ermine Moths, European Corn Borer, San José and other scale insects, etc., were intercepted. Field scouting to reduce the infestation of the Brown-tail Moth in New Brunswick and Nova Scotia has been very successful. In addition, other scouting work has been conducted for such introduced pests as the European Corn Borer and the European has been conducted Apple Sucker as a result of which areas have been quarantined in Ontario, for the former insect and in Nova

Scotia for the latter. On April 21st, 1922, the Destructive Insect and Pest Act Advisory Board was created. The Dominion Entomologist was appointed Chairman of the Board and the Chief of the Division of Foreign Pests Suppression, Secretary. The revised regulations under the Destructive Insect and Pest Act went into effect on Sept. 1st, 1923, and were published as "Acts, Orders and Regulations No. 8, Dept. of Agriculture". This Division now maintains an inspection service at Halifax, N. S; St. John, N. B; Quebec, Que; Montreal, Que; Niagara Falls, Ont; Toronto, Ont; Windsor, Ont; Ottawa, Ont; Winnipeg, Man; and Vancouver, B. C.

Division of Systematic Entomology

The care and development of the National Collection of Insects is the chief concern of the officers of this division; taxonomic research, therefore, occupies much of their time. During the last ten years this collection has been enlarged very materially and excellent progress has been made in classifying the various orders of insects and describing numbers of species new to science, the types of which are deposited in the Entomological Branch. Such well known collections as the Harrington collection of Hymenoptera, the Woolly-Dod collection of Noctuidae, and the Sladen collection of wild bees, have been incorporated into the National Collection. This latter is undoubtedly becoming one of the most important collections of insects in North America, and as a consequence is of increasing value to economic workers, both federal and provincial. The following well known foreign specialists have visited Ottawa, during the period covered by this paper, for the purpose of examing material in the National Collection: J. M. Aldrich, H. G. Dyar, A. Busck, S. A. Rohwer, A. B. Gahan, W. Barnes, T. L. Casey, J. H. Emerton, W. T. M. Forbes, E. C. Van Dyke and H. J. Elwes.

Dr. McDunnough during recent years has made a special taxonomic study of the Ephemerida an insect order which has been much neglected by systematists. These insects, as is well known, are of considerable economic importance as food for fish. Other important studies have related to the Tabanidae by Dr. McDunnough, the Syrphidae and other dipterous groups by Mr. C. H. Curran, and parasitic and other hymenoptera by Mr. H. L. Vierick.

Introduction of Parasites of the Gipsy and Browntail Moths.

The introduction into eastern Canada, of parasites of the Gipsy and Browntail moths which was begun in 1912, was developed to a considerable extent in later years, such work being largely under the immediate direction of Messrs. J. D. Tothill and L. S. McLaine, assisted by Messrs. A. B. Baird, A. G. Dustan and R. P. Gorham. Up to 1917, the total number of parasites of the above

two moths imported from Massachussetts through the co-operation of the United States Bureau of Entomology, and liberated at strategic points in the provinces of Nova Scotia, New Brunswick and Quebec, were: *Apanteles lactiecolor* 37,500; *Compsilura concinnata* 30,725, and *Calosoma sycophanta*, 4,200. The importation of these enemies of the Gipsy and Browntail moths was discontinued in 1917, in order that more recovery work of the enemies introduced might be undertaken. The parasites mentioned have undoubtedly become established in eastern Canada, as they have been recovered on several occasions; the *Calosoma* has also been recovered.

Aid to Greater Production Campaign

The greater production campaign inaugurated by the Government during the Great War was aided considerably by entomologists throughout Canada, through lectures, correspondence and publications. A special series of articles of value to citizens engaged in war-garden work was prepared at Ottawa and given to the press at timely intervals. The late Dominion Entomologist, Dr. G. Gordon Hewitt, personally took a keen interest in the protection of stored grain from rats, mice and insects, and also prepared, for the Food Controller, a statement, issued in leaflet form, instructing householders as to methods of keeping breakfast foods and other products kept in store free from insect enemies. The federal Entomological Branch issued a series of circulars on important pests which were called "Crop Protection Leaflets." During this time too, the Branch adopted the slogan, "Crop Protection means Crop Production". The late Dr. Hewitt also prepared a leaflet entitled, "The Suppression of Two Insects affecting Troops", which was issued by the Department in 1916 for special distribution among the Canadian Expeditionary Forces.

Greenhouse Insect Investigations

At Ottawa and Vineland, studies have been undertaken of a number of the more important greenhouse insects, and a special bulletin on the subject was published in 1923.

Other Investigations.

Studies of insects affecting stored products, live stock, man and his personal belonging, etc., have also been investigated at Ottawa as opportunity offered. Fruit insect investigations, insecticide investigations and natural control investigations, have been specially conducted at certain field laboratories during the past decade and reference to such investigations will be made under the provinces in which they were undertaken.

Field Laboratories

In 1914, the Dominion Entomological Branch had nine field laboratories, each in charge of a trained entomologist. These laboratories were located at Bridgetown, N. S.; Fredericton, N. B.; Covey Hill, Que.; Jordon Harbour, Ont.; Strathroy, Ont.; Treesbank, Man.; Lethbridge, Alta.; Agassiz, B. C.; and Vancouver, B. C. In 1924, the Branch maintained 20 laboratories, namely, at Annappolis Royal, N. S.; Kentville, N. S.; Wolfville, N. S.; Fredericton, N. B.; Hemmingford, Que.; Aylmer, Que.; Ottawa, Ont.; Vineland, Ont.; St. Thomas, Ont.; Port Stanley, Ont.; Strathroy, Ont.; Treesbank, Man.· Indian Head, Sask.; Saskatoon, Sask.; Lethbridge, Alta.; Banff, Alta.; Vernon, B. C.; Nicola, B. C.; Agassiz, B. C.; and Victoria, B. C. All of these with the exception of Kentville, Wolfville, St. Thomas, Port Stanley, Banff and Nicola, may be regarded as permanent in nature.

Library.

During the last ten years the library of the Entomological Branch, established at Ottawa, has assumed important proportions, and it is now undoubtedly one of the best libraries of its kind in Canada. Sets of most of the entomological journals of the world have been completed and many rare and valuable works of reference for the systematist added. The series of economic bulletins, reports, etc., published by various states and governments have also been largely added to, and an endeavor is being made to receive all current literature as issued.

Publications.

Up to 1914, the federal Department had published 6 Entomological Bulletins and 2 Circulars. From 1914 to 1923 inclusive, 18 Entomological Branch Bulletins, 13 Entomological Branch Circulars, 16 Crop Protection Leaflets, 4 Entomological Circulars (Department of Agriculture, New Series), and 7 Entomological Pamphlets (Department of Agriculture, New Series) were published. These are as follows:

Bulletins :

No. 7.—Forest Insect Conditions in British Columbia.—By J. M. Swaine, 1914.
8.—The Strawberry Root Weevil in British Columbia.—By R. C. Treherne, 1914
9.—The Army-worm.—By Arthur Gibson. 1915.
10.—Cutworns and their control.—By Arthur Gibson. 1915.
11.—The Hessian Fly and the Western wheat stem Sawfly.—By Norman Criddle. 1915.
12.—The Cabbage Root Maggot and its Control in Canada.—By Arthur Gibson and R. C. Treherne. 1916.
13.—The Army Cutworm.—By E. H. Strickland. 1916.
14.—Canadian Bark Beetles.—By J. M. Swaine, 1917.
15.—The Pear Thrips and its control in British Columbia.—By A. E. Cameron and R. C. Treherne. 1918.

16.—The Apple Bud-moths and their Control in Nova-Scotia.—By G. E. Sanders and A. G. Dustan. 1919.
17.—The Fruit worms of the apple in Nova Scotia.—By G. E. Sanders and A. G. Dustan. 1919.
18.—Studies in North America Cleorini (Geometridae).—By J. H. McDunnough, 1920.
19.—The Natural Control of the Fall Webworm in Canada.—By J. D. Tothill. 1922.
20.—The Morphology and Biology of a Canadian Cattle-infesting Black Fly.—By A. E. Cameron. 1922.
21.—Insects affecting Greenhouse Plants.—By Arthur Gibson and W. A. Ross. 1922.
22.—Biological Notes on Parasites of Prairie Cutworms.—By E. H. Strickland. 1923.
23.—North American Cerambycid Larvae.—By F. C. Craighead. 1923.
24.—Insects affecting Live Stock.—By S. Hadwen. 1923.

Circulars:

No. 3.—The Chinch Bug in Ontario.—By H. F. Hudson. 1914.
4.—Instructions to Importers of Trees, Plants and other Nursery Stock into Canada.—By C. G. Hewitt. 1914.
5.—The Control of Locusts in Eastern Canada.—By Arthur Gibson. 1915.
6.—The Control of Cutworms in the Prairie Provinces.—By. E. H. Strickland. 1916.
7.—Results from Spraying in Nova Soctia.—By G. E. Sanders and W. H. Brittain. 1916.
8.—Spraying for Insects affecting apple orchards in Nova Scotia. By G. E. Sanders and W. H. Brittain. 1916.
9.—Common Garden Insects and their control.—By Arthur Gibson. 1917. Reprinted in 1921.
10.—Regulations under the Destructive Insect and Pest Act. By C. G. Hewitt. 1917.
11.—The White-marked Tussock Moth and Its Control.—By J. M. Swaine and G. E. Sanders. 1918.
12.—Directions for Collecting and Preserving Insects.—By J. H. McDunnough. 1919. Reprinted as Pamphlet No. 14, N. S., Dept. of Agric., 1922; Revised Edition, 1923.
13.—Locust Control in the Prairie Provinces.—By Norman Criddle. 1920.
14.—Boring Caterpillars Affecting corn and other crops and which are liable to be mistaken for the European Corn Borer.—By Arthur Gibson. 1920.
15.—The Control of Bark-beetle outbreaks in British Columbia.—By Ralph Hopping. 1921.

Crop Protection Leaflets :

No. 1.—Protection of Crops.—By C. G. Hewitt. 1917.
2.—Prepare to Protect your crops next Season.—By C. G. Hewitt. 1917.
3.—Cutworms and Their Control.—By Arthur Gibson. 1918. Reprinted 1919.
4.—Root Maggots and Their Control.—By Arthur Gibson. 1918.
5.—Prevent White Grub Injury.—By Arthur Gibson. 1918.
6.—How to Control Locusts or Grasshoppers.—By Arthur Gibson and Norman Criddle, 1918. Reprinted, 1919.
7.—Rats and Mice.—By C. G. Hewitt. 1918.
8.—Aphids or Plant Lice.—By W. A. Ross. 1918. Enlarged and reprinted 1923, as Pamphlet No. 31, N.S., Department of Agriculture.
9.—The Pea Weevil.—By Arthur Gibson. 1918.
10.—Arsenate of Lime.—By G. E. Sanders. 1918.
11.—The date on which it is Safe to reseed fields in the Prairie Provinces after they have been devastated by Cutworms.—By E. H. Strickland. 1921.
12.—The Beet Webworm.—By E. H. Strickland, and N. Criddle 1919. Reprinted as Circular No. 14, Department of Agriculture, 1923.
13.—The European Corn Borer.—By Arthur Gibson and L. S. McLaine. 1920.
14.—The Control of Grasshoppers.—By Norman Criddle and A. V. Mitchener. 1921.
15.—The Pale Western Cutworm.—By H. L. Seamans and E. H. Strickland. 1921.
16.—The Control of the European Corn Borer.—By H. G. Crawford and J. G. Spencer. 1921.

Department of Agriculture Circulars:

No. 2.—Field Crop Insects.—By H. F. Hudson. 1922.
4.—The date on which it is safe to reseed fields in the Prairie Provinces after they have been devastated by the Pale Western Cutworm.—By H. L. Seamans and E. H. Strickland. 1922.
12.—How to Foretell Outbreaks of the Pale Western Cutworm in the Prairies Provinces.—By H. L. Seamans, 1923.
14.—The Beet Webworm.—By E. H. Strickland and N. Criddle. 1923.

Department of Agriculture Pamphlets:

No. 5.—The Strawberry Root Weevil.—By W. Downes. 1922.
6.—The Western Wheat-Stem Sawfly and its Control.—By Norman Criddle. 1922.
30.—The Hessian Fly in the Prairie Provinces.—By Norman Criddle. 1923.
32.—Root Maggots and their Control.—By R. C. Treherne. 1923.
33.—Wireworm Control.—By R. C. Treherne. 1923.

Reports of the Canadian Arctic Expedition

The insect reports published by the Dominion Government were completed in 1921. The various parts are as follows:

INTRODUCTION.—By C. Gordon Hewitt.
Part A: Collembola.—By Justus W. Folsom.
Part B: Neuropteroid Insects.—By Nathan Banks.
Part C: Diptera
Crane-flies.—By Charles P. Alexander.
Mosquitoes.—By Harrison G. Dyar.
Diptera (Excluding Tipulidae and Culicidae).—By J. R. Malloch.
Part D: Mallophaga and Anoplura.
Mallophaga.—By A. W. Baker.
Anoplura.—By G. F. Ferris and G. H. F. Nuttall
Part E: Coleoptera.
Forest Insects, including Ipidae, Cerambycidae, and Buprestidae.—By J. M. Swaine.
Carabidae and Silphidae.—By H. C. Fall.
Coccinellidae, Elateridae, Chrysomelidae and Rhynchophora (excluding Ipidae). By C. W. Leng.
Dytiscidae.—By J. D. Sherman, Jr.
Part F: Hemiptera.—By Edward B. Van Duzee.
Part G: Hymenoptera and Plant Galls.
Sawflies. (Tenthredinoidea).—By Alex. D. MacGillivray.
Parasitic Hymenoptera.—By Charles T. Brues.
Wasps and Bees.—By F. W. L. Sladen.
Plant Galls.—By E. Porter Felt.
Part H: Spiders, Mites, and Myriapods.
Spiders.—By J. H. Emerton.
Mites.—By Nathan Banks.
Myriapods.—By Ralph V. Chamberlain.
Part I: Lepidoptera.—By Arthur Gibson.
Part J: Orthoptera.—By E. M. Walker.
Part K: General Observations on Insect Life in the Arctic.—By Frits Johansen.

Health of Animals Br anch, Department of Agriculture.

In 1916 this Branch published two bulletins as follows:

No. 21.—A Further Contribution on the Biology of *Hypoderma lineatum*.—By S. Hadwen.
22.—Observations on the Migration of Warble larvae through the Tissues.—By S. Hadwen and E. A. Bruce.

Imperial Bureau of Entomology.

The federal Entomological Branch assists, by contribution, in the upkeep of the Imperial Bureau of Entomology, and the Dominion Entomologist is a member ex-officio of the Management Committee. This Bureau established in 1913, is directed by Dr. Guy A. K. Marshall, assisted by Dr. S. A. Neave. It is maintained by contributions from the Imperial Government and the various Governments of the Empire. It is splendidly organized, is in touch with the chief entomologists throughout the Empire, assists in identification of doubtful material, and above all publishes *The Review of Applied Entomology* and *The Bulletin of Entomological Research*, of which the former especially, is of undoubted value to entomologists the world over.

The Imperial Bureau of Entomology has also been of assistance to Canadian entomologists in the granting of studentships for post graduate work. Messrs. J. D. Tothill and A. B. Baird of the federal service were assisted in this way. Dr. W. H. Brittain, Provincial Entomologist for Nova Scotia, was also granted a studentship.

The Honorary Advisory Council for Scientific and Industrial Research.

This Council has rendered immediate assistance in furthering entomological research; in 1919, it granted a studentship to Mr. Eric Hearle to permit him to undertake mosquito investigations in the Lower Fraser Valley, B. C., under the direction of the Dominion Entomologist. In 1921, Mr. Alan G. Dustan, of the Entomological Branch, was awarded a studentship to enable him to take up post graduate work on insect diseases, but owing to ill health he could not take advantage of this.

Progress in the Provinces.

NOVA SCOTIA

Federal:

The officers at the Annapolis Royal laboratory have been, during recent years, specially engaged in the development of improved and cheaper insecticides. Mr. Geo. E. Sanders had charge of this work until March, 1922, when he resigned to enter commercial work, since which date Mr. Arthur Kelsall has been in immediate charge. The success which has attended the work of these insecticide entomologists has indeed been remarkable. As stated in my report as Dominion Entomologist for the two years ending March, 1921, these researches have been of a comprehensive nature involving chemical studies of the insecticides under consideration, insectary studies on the effect of insect poisons, etc. As a result spray and dust calendars have been devised.

One of the important results of this work was the development and advancement of the dust method of pest control. The dust invented by Mr.

Sanders composed of dehydrated copper sulphate, calcium arsenate and hydrated lime, came rapidly into general, use not only in Canada but also throughout the United States and in other countries. Coincidentally better types of power dusters were manufactured, and each year brought a reduction in the price of the materials used due to more up-to-date methods of making and distribuing and to the larger scale on which such materials were being handled. Methods were developed for the utilization of white arsenic as an insecticide in Bordeaux mixture.

Other lines of investigation have received attention; the compatibility of various insecticides with various fungicides, foliage injuries resulting from sprays and dusts, their cause and prevention, insect repellents and attractants, new uses for insecticides, relative tests and efficiency of new insecticides, and so on.

More recently other new lines of work have been commenced. Among the more prominent of these may be mentioned the utilization of nicotine fumes and other gases as insecticides in connection with power-dusting machines, a study of various spray and dust "spreaders" and "stickers" and a study of the absorption of water-soluble arsenic by various materials.

Investigations of important fruit insects have also been conducted by officers attached to the Annapolis laboratory, such as life-history studies and control of the bud moths affecting apple, the fruit worms attacking orchard trees, the White-marked Tussock moth, the Green Apple Bug, the European Apple Sucker, etc., as well as certain insects affecting field and vegetable crops such as the Army Worm, the Colorado Potato Beetle, etc. For field crop work, a temporary laboratory was established at Kentville, in 1923. In insecticide and other investigations, our officers have had close co-operation with Prof. S. Blair, Superintendent of the Experimental Farm at Kentville.

The European Apple Sucker, *Psyllia mali* Schmidb., was first found in Nova Scotia in 1919 in the vicinity Wolfville, and has since spread through Kings county and into the counties of Annapolis, Hants, Colchester, Cumberland, Halifax and Lunenberg. In order to assist in the prevention of the spread of this insect from the Province of Nova Scotia, the federal Department of Agriculture placed the above areas under quarantine and no nursery stock liable to introduce the pest into new sections is allowed to be moved. In 1920, it was noted that a fungous disease, *Entomophthora sphœrosperma* Fres., was attacking the Apple Sucker, and Mr. Allan G. Dustan was detailed to make an intensive study of the parasite with the end in view of assisting in its natural spread. This work has been remarkably successful, and in areas where the fungus was introduced artificially in 1922 and 1923, the Apple Sucker was practically exterminated. The provincial entomological laboratory at Wolfville was placed at our disposal. In 1920, Mr. Dustan also undertook a study of a fungous disease parasitic on the Green Apple Bug, *Lygus communis novascotiensis* Knight.

The winter scouting work for the nests of the Brown-tail Moth, conducted by the Division of Foreign Pests Suppression, in co-operation with the provincial Department of Agriculture, has assisted very materially in controlling this pest. During the winter of 1913-1914, 24,156 nests, containing living caterpillars were gathered. This number has been noticeably reduced during succeeding winters; in 1922-1923, only 492 winter nests were found. Altogether during the ten years under review 73,756 nests were collected in this province. Mr. F. C. Gilliatt has been locally responsible for the carrying on of this work during the past five years.

Mr. Joseph Perrin, of McNabs Island, has assisted the Division of Foreign Pests Suppression in the inspection of imported nursery stock at the port of Halifax since October 1913. Mr. Perrin has continued to take a keen interest in entomology, particularly in lepidoptera, and has brought together a collection of the local species which is undoubtedly of considerable importance.

Provincial

The staff of the Provincial Entomologist, Dr. W. H. Brittain, has been added to during recent years and an entomological laboratory established at Wolfville. This laboratory has been mainly concerned in problems relating to fruit growing. In all of this work a close co-operation with the federal service has been maintained. At Truro, studies of insects attacking vegetables were undertaken, the Cabbage Root maggot, *Hylemya brassicæ* Bouché, being especially investigated. For a period of nine years the latter insect was under close observation and the details of its control under Nova Scotia conditions thoroughly worked out.

The Department has published valuable bulletins, particularly on the Apple Maggot, the Green Apple Bug, the Apple Sucker, and the Potato Stem Borer. Recently ,material has been collected for a handbook of Nova Scotia insects and it is expected that this publication will contain an illustration of every insect included.

In connection with the Brown-tail Moth winter work directed by the federal Entomological Branch, the Department of Agriculture for Nova Scotia has contributed officers to assist in this work.

Agricultural College, Truro.

Several changes have been made in the legislation relating to insect pests during the past ten years. The Provincial Entomologist is the executive officer appointed for the purpose of carrying out the regulations under the act. The "Foul Brood Act" 1913, dealing with the prevention and treatment of diseases among bees is also administered by the Provincial Entomologist.

Soon after the discovery of the San José Scale in Nova Scotia in 1912, the Department established fumigation stations at Dibgy and Truro, for the purpose of treating all nursery stock entering the province. In 1920, these stations were closed and all shipments subject to fumigation were, thereafter, treated at a federal station. The province then required all shipments for Nova Scotia from provinces known to be infested by the San José Scale, to be fumigated before shipment under the direction of a provincial officer. In 1923, an order-in council was passed amending the regulations to conform with the federal regulations under the Destructive Insect and Pest Act dealing with the importation of plants and plant products.

In addition to the regular course in entomology given at the college, by the Provincial Entomologist and Professor of Entomology, short courses have been held in various parts of the province and at these the control of farm pests has been explained directly to the farmers. These short courses have done much to educate those in attendance in matters relating to insect control and many are putting the knowledge thus gained into practice.

The Acadian Entomological Society

This society which until 1921 was known as the Entomological Society of Nova Scotia, has continued to publish important transactions. The Provincial Department of Agriculture for Nova Scotia contributed the sum of $300 in 1921 and $400 in 1922 towards assisting the society in its work, particularly in connection with its annual publications. These transactions contain very valuable contributions: the last number (No. 8) comprised 182 pages and had 25 full page plates of original figures.

The Halifax Institute of Science

Mr. Harry Piers has aided in no small way in the development of entomology in the province. As curator of the museum maintained by this society, he has been in a position to give information regarding insects, and in the Transactions of the Institute has published an important paper on the Orthoptera of Nova Socita, having been assisted in this publication by Mr. C. B. Gooderham, who at the time was attached to the Agricultural College at Truro, N. S.

NEW BRUNSWICK

Federal

In 1914, a small portable structure was used as the federal laboratory, space for which was provided on the grounds of the University of New Brunswick at Fredericton. The following year (1915) a permanent brick building of two stories was erected, an in 1917 an excellent insectary was added. The work at this laboratory was under the joint direction of Messrs. J. D. Tothill and L. S. McLaine, until 1918 when the latter officer was transferred to Ottawa.

The officers attached to the Fredericton laboratory have made special studies of the natural control of native insects and have also had charge of the introduction and establishment in eastern Canada of the parasitic and predaceous enemies of the Brown-tail and the Gipsy Moths. A bulletin on these two latter insects prepared by Messrs Tothill and McLaine was published by the Provincial Department of Agriculture in 1914. The natural control of the Fall Webworm, *Hyphantria cunea* Dru, the Forest Tent Caterpillar, *Malacosoma disstria* Hbn., and the Spruce Budworm, *Harmologa fumiferana* Clem. was specially studied by Dr. Tothill and his assistants. An important bulletin of 107 pages, entitled, "The Natural Control of the Fall Webworm" was published in 1922. In 1916, Dr. Tothill studied the natural control of the Oyster-shell Scale, *Lepidosaphes ulmi* L.; about 10,000 egg masses from several provinces were examined and it was found that the mite, *Hemisarcoptes malus* Shimer w as the most important single factor in control. An investigation on the natural control of the White-marked Tussock moth, *Hemerocampa leucostigma* S. & A. was commenced in 1917, and the results published by Mr. A. G. Dustan in 1923. In the same year, a study of the natural control of the Cherry-tree Ugly-nest Tortricid, *Cacœcia cerasivorana* Fitch, was completed by Mr. A. B. Baird and a paper resulting therefrom published in 1918. More recently with the increase of the Larch Sawfly, *Lygœonematus erichsonii* Hartig.

in eastern Canada special life-history and parasite studies of the sawfly have been directed from the Fredericton laboratory.

The outbreak of the Spruce Budworm, *Harmologa fumiferana* Clem., first observed in New Brunswick in 1912, has been under continuous study by Dr. Swaine and Dr. Tothill, and in 1921-23, by Dr. F. C. Craighead of the Division of Forest Insects, Ottawa. Camps were established at Bathurst and other places during the progress of this investigation. Mr. M. B. Dunn of the federal staff, also assisted in this work. The natural control of the insect was specially studied by Dr. Tothill. The results of all of these spruce budworm studies are now being prepared for publication.

Following the inception of a close biological study of the Colorado Potato beetle, *Leptinotarsa decemlineata* Say, at Ottawa, in 1919, the bionomics of the insect in New Brunswick were undertaken by Mr. R. P. Gorham in 1921, and in this and following years much data was obtained.

In 1923, a reorganization of the staff employed at the Fredericton laboratory was effected, Dr. Tothill being transferred to the Division of Forest Insects, Mr. Baird to parasite studies at Ottawa, and Mr. Dustan to investigations relating to diseases of insects, in Nova Scotia. Mr. L. J. Simpson was retained at the Fredericton laboratory to assist Dr. Tothill. Insecticide investigations conducted from the Fredericton laboratory during 1922 and 1923 have been under the immediate charge of Mr. G. P. Walker. Control demonstrations in potato fields and in apple orchards have been of much value. In this work we have had the co-operation of the Superintendent of the Expermental Farm and, also, of the Provincial Horticulturist.

The federal fumigation station erected at St. John, N.B., in 1913, has during the period of this review, been in charge of Mr. H. E. Goold who has also assisted in the inspection of imported nursery stock. In 1923, this station was closed with the coming into effect of the revised regulations under the Destructive Insect and Pest Act. In order to assist, however, in the inspection of plant products arriving at the Port of St. John an office of the Entomological Branch was established there in 1923, Mr. Arthur Finnamore being placed in charge.

As in Nova Soctia, co-operative work in scouting for the nests of the Brown-tail moth, was conducted with the Department of Agriculture for New Brunswick. During the winter of 1913-14, as many as 28,100 nests were collected. In 1914-15, only 239 winter nests were found; in 1915-16, 395 nests; in 1916-17, 375 nests; and in 1917–18, 62 nests. Scouting carried on every winter since, has failed to find a single nest.

Provincial

For a number of years previous to 1923, Mr. William McIntosh, as Provincial Entomologist, published an annual statement discussing in brief the seasonal occurrence of injurious insects. Mr. McIntosh established an excellent connection with the school teachers of the province and this has enabled him to build up an extensive correspondence. He has, in addition, for some years taught nature study, including entomology, at the summer school for teachers conducted at Sussex, N.B. The Department has recently made a yearly grant of $200 to the Acadian Entomological Society.

Crown Lands Department.

Officers of this provincial Department have co-operated with entomologists of the federal service in forest insect survey work and other related investigations. In this connection Col. T. G. Loggie, the Deputy Minister, and Mr. G. H. Prince, the Chief Forester, have been active.

University of New Brunswick

During recent years an elementary course on forest insects has been given at the University of New Brunswick. This has been under the guidance of Professor A. V. S. Pulling. Dr. J. D. Tothill of the Dominion Entomological Branch has assisted in the course.

Other Activities

The Fredericton Science Club and the Natural History Society of New Brunswick have held lectures on various entomological subjects.

PRINCE EDWARD ISLAND

Federal

Officers attached to the Annapolis Royal, N.S., laboratory have on occasions, during recent years visited sections of the Island to investigate outbreak of grasshoppers and other insects. Much of the entomological work, however, has been conducted by correspondence. In 1918 insecticide investigations were conducted at Charlottetown, plots of potatoes for the purpose being placed at our disposal by the Superintendent of the Experimental Farm. Various dusts and sprays were used, the work being directed from the above laboratory. In 1923, Mr. J. A. Clark, Superintendent of the Farm, assisted our officers in connection with an outbreak of grasshoppers.

No provincial entomological service has been established.

QUEBEC

Federal

The federal laboratory at Covey Hill, Que. was moved to Hemmingford, in 1915. Mr. C. E. Petch who has been in charge of this laboratory has been engaged particularly in fruit insect investigations. Largely through his efforts, the proper spraying and care of orchard trees, as a means of protective them from insect pests, has been brought to the attention of the growers with excellent results. As an indication of the development in the sale of insecticides in Quebec province during recent years, Mr. Petch has given this subject special study, and from a statement he has given us, I have taken the following: Previous to 1911, Paris green was practically the only insecticide used in the province, but during the 10 years 1911 to 1921 there was a steady increase in the sale of

other insecticides. For instance, in the latter year, 194,000 pounds of Paris green were sold, and 80,600 pounds of other insecticides. The latter amount included, 60,000 pounds of arsenate of lead which up to 1918 had been used sparingly except in certain of the apple growing sections. The value of insecticides used by farmers of the province in 1921 was $175,000, according to Mr. Petch.

Special studies of the bionomics and control of the Apple Maggot, *Rhagoletis pomonella* Walsh, the Plum Curculio, *Conotrachelus nenuphar* Herbst., and the Apple Curculio, *Anthonomus quadrigibbus* Say, have been undertaken by the officer in charge of our laboratory at Hemmingford and the results of control studies have been demonstrated in commercial orchards. A practical apple-orchard spray calendar prepared by Mr. Petch, in collaboration with Mr. G. Maheux, the Provincial Entomologist, is being followed by many fruit growers of the province. Important data have also been secured on the value of dusting orchard trees and the spraying and dusting of potatoes. Demonstrations in the dusting and spraying of apple orchards in co-operation with the provincial Department of Agriculture, have been conducted in the important fruit centres. At the Hemmingford laboratory, too, investigations on live stock insects, particularly warble flies, have been undertaken. As mentioned in the report of the Dominion Entomologist for 1917 and 1918, "Cattle which were given the protection of an open shed during 1916, were found to be free from warbles in 1916, thus demonstrating the value of shade into which the warble flies appear to be disinclined to penetrate."

Forest insect investigations in Quebec province during the past ten years have made much progress. The outbreak of the Spruce Budworm, *Harmologa fumiferana* Clem., has enabled officers of the Division of Forest Insects, particularly Drs. Swaine and Craighead, to undertake intensive studies. Ground and air surveys of infested territory have been made and a mass of scientific data obtained and, as mentioned previously, much of this information will soon be published. In 1916, studies of dying spruce on the Black and Nation Rivers, were incepted by Dr. Swaine; the Four-eyed Spruce Bark-beetle, *Polygraphus rufipennis* Kby., being found to be directly associated with the injury. In 1917, a temporary forest insect laboratory was established at Fort Coulonge, Que., to investigate the life-histories and control of cerambycid and buprestid beetles. During recent years several summer camps for the study of forest insects have been established in Quebec province, as for instance at Lake Edward and Lac Tremblant, and a special study of the Destructive Eastern Spruce Bark-beetle, *Dendroctonus piceaperda* Hopk., in Quebec province is in progress. In the Gaspé area, valuable spruce stands are affected. Other important bark-beetles are also being investigated. A forest insect laboratory was erected at Aylmer, Que., in 1920, with Mr. C. B. Hutchings in charge. At this laboratory such important pests as the Bronze Birch Borer, *Agrilus anxius* Gory; the Oak Carpenter Worm, *Prion oxystus macmurtrei* Guer.; the Birch-leaf Skeletonizer, *Bucculatrix canadensisella* Chamb., etc., have been studied. Forest insect material is sent to this laboratory from the forests of Quebec and Ontario for biological studies.

During the year 1915, the writer directed a widespread grasshopper campaign in affected localities in Quebec province with the assistance of Messrs. Petch, Beaulieu and Beaulne, of the federal service, and resident parish priests. In all, 33,000 acres of growing crops (oats, hay, etc.), were treated with poisoned bait, as a result of which a reestablishment of agriculture in the infested regions was possible. This was the first large field crop control campaign

conducted in eastern Canada. The provincial Department of Agriculture made grants to the affected parishes, to assist the farmers in the purchase of bran, Paris green, etc.

In 1923, in co-operation with the Entomological Department of Macdonald College, investigations in truck crop insects were undertaken in the Montreal district, special attention being given to the control of the onion maggot, *Hylemyia antiqua* Meig.

In the development of the plant inspection service, an office of the Entomological Branch, was established in Montreal, in 1918, and for a number of years the work conducted from this office was in charge of Mr. J. I. Beaulne. This officer left our service in 1923, his place being taken by Mr. W. St. G. Ryan. With the coming into effect of the revised regulations of the Destructive Insect and Pest Act, in Sept. 1923, the fumigation station at St. John's, Que., was closed.

During the years 1922 and 1923, the Division of Foreign Pests Suppression undertook scouting work in the southern areas of Quebec province in order to see if the Gipsy moth had become established. In 1923, in view of the discovery of an important outbreak at Alburgh, Vermont, special scouting was undertaken in southern Quebec, particularly in the area adjourning that state. In this work, we were assisted by trained scouts, kindly loaned to us by the United States Bureau of Entomology.

Provincial

The provincial Department of Entomology was organized in 1914, in which year legislation for the "Protection of Plants from Destructive Insects and Fungoid Diseases", was passed. The Rev. Canon Huard was the first Provincial Entomologist and occupied the position form 1914 to 1915, in which latter year, Mr. George Maheux succeeded him. Mr. Maheux continues to direct in a very efficient manner the entomological activities of the Department. At first, nursery inspection was the work which chiefly occupied the time of the entomologist, but since 1916, the provincial activities have broadened considerably and under Mr. Maheux's direction valuable results have been accomplished. Much educational work has been undertaken, information relating to the control of insects being disseminated by means of lectures, bulletins, control demonstrations, spray calendars, etc. In this work, Mr. Omer Caron has assisted since 1921.

Nurseries in the province are inspected at regular intervals. During the last four years special demonstrations in spraying have been given each year on 160 farms. In addition, similar demonstrations have been given on 60 fruits farms, 40 vegetable plots and 60 small fruit plantations. The work on some of the larger fruit farms has been carried on in close co-operation with the Dominion Entomological Branch. County entomological work was started in 1922, with an officer in charge. Control demonstrations have been carried out with such insects as grasshoppers, root maggots, tent caterpillars, cutworms, potato beetle, etc., and all of this work has convinced the farmers of the efficiency of the measures of control. In 1918, the existing legislation was amended, giving the Provincial Executive Council authority to take action against any pest when deemed necessary. In 1920, the legislation of 1909, relating to "The Protection of Bees", was amended to increase the fine to be paid by any person who sprays fruit trees in bloom.

Macdonald College

In 1914, the entomological staff at Macdonald College consisted of Prof. W. Lochhead, Mr. E. M. DuPorte, and Mr. P. I. Bryce. Mr. DuPorte devoted a large portion of his time for six years to research, but gave a few lectures on special topics to advanced students. In 1920, on the departure of Mr. Bryce, he was appointed Lecturer, and his time has been largely devoted to advanced classes. During this period, he published a number of important papers, such as, "The Nervous System of *Sphida obliqua*"; "Death-feigning Reactions on *Tychius picirostris*"; "The Life-history and Control of the Bud Moth"; "The Structure and Functions of the Proventriculus of *Gryllus*"; "The Propleural and Pronotal Sulci in the Orthoptera"; "Studies of *Coccobacillus acridiorium* and other Intestinal Organisms of Locusts"; "The Muscular System of *Gryllus assimilis*"; "Studies of *Spirochaeta duttoni*", and various shorter papers on economic subjects.

In 1919, Prof. Lochhead published his "Class Book of Economic Entomology" (Blakistons) which is used in a number of educational institutions. He has also contributed many papers on entomological subjects to the Annual Reports of the Entomological Society of Ontario, the Quebec Society for the Protection of Plants, and the Pomological Society of Quebec; and to "The Journal of Agriculture", and other publications. A number of circulars have also been prepared for the use of Quebec orchardists and gardeners.

Among the economic insects the life-histories of which have been studied are:—the Bud Moth, the Onion Maggot, flea beetles, and the control of grasshoppers.

At the present time, the entomological staff consists of Prof. Lochhead, Dr. E. M. DuPorte, and Mr. A. D. Baker. An important feature of the instruction is the attention given to post-graduate students working for the Master's degree. The large amount of time and energy required for classroom work on the part of the staff has necessarily limited the length of time that could be devoted to economic studies.

Agricultural College, Oka.

At this institution, the position of Professor of Entomology was established in 1915, and Prof. F. Letourneau received the appointment. Courses in entomology were developed and, in addition, instruction in field work was given. In all of this work, Father Leopold has undoubtedly been the guiding hand, the investigations of the latter, particularly with regard to spraying problems, having been most valuable.

Montreal Entomological Society (Montreal Branch of the Entomological Society of Ontario)

In 1923, this society celebrated its fiftieth annual meeting. During the years under review regular meetings have been held at which papers were presented and specimens exhibited. The society has, indeed, an enviable record. In its continued progress, Messrs. A. F. Winn and G. A. Moore have taken a leading part.

Lyman Request Committee.

Under the terms of the will of the late Henry H. Lyman, of Montreal, who died in 1914, his entomological collections and library with a sum of money for their upkeep, were bequeathed to McGill University. These bequests were accepted by the University authorities, and in due course a room in the Redpath Museum was allotted for them housing of the collection and library. The Dominion Entomologist is a member of the Committee in charge. During the last ten years the collection and library have been considerably added to, and the general curatorship of them has been undertaken by Mr. A. F. Winn.

The Quebec Society for the Protection of Plants.

This society, established in 1908, has continued to hold its annual meetings at Macdonald College, at which valuable papers on entomological subjects have been presented. These contributions have been duly published in the excellent series of yearly reports issued. The society has certainly accomplished much useful work and the gatherings held under its auspices and the resultant publications have been of direct benefit to farmers, fruit growers, gardeners and others.

Other Activities

Since 1914, limited courses in entomology have been given at the Laval Forest School and at the Agricultural School at Ste-Anne de la Pocatière. At the latter school, the position of Professor of Botany and Entomology, 1914-1923, was occupied by Mr. George Bouchard.

The 25th anniversary of the Abbé Provancher's death was celebrated in Quebec city, in 1918, and a bronze tablet was erected to his memory in the Provincial Museum. In the following year, the Society Provancher d'Histoire Naturelle was founded, its aim being to assist in general zoological studies, more particularly, however, in endeavors such as those fostered by the American Audubon Society.

ONTARIO

Federal

With the separation of the entomological service from the Experimental Farms Branch in 1914, the Entomological Branch thus constituted, was given quarters in the Birks Building, Ottawa, and now occupies the two upper floors of this building. The Divisional organization of the Branch has been referred to in the beginning of this review

The Branch in addition to the Ottawa laboratories and insectary, maintains two permanent laboratories in Ontario, namely, at Vineland Station and Strathroy; and two temporary laboratories, namely, at Port Stanley and St. Thomas.

The work of the officers resident at Ottawa, has, in general, been referred to. Mention however, might, briefly be made here of certain special investigations conducted in the Ottawa district. In 1914 and 1915, grasshopper control experiments were conducted by the writer near Bowesville. In the

latter year the Lesser Migratory Grasshopper, *Melanoplus atlanis* Riley was enormously abundant and, to a lesser extent, the Pellucid Grasshopper, known in the west as the Roadside Grasshopper, *Camnula pellucida* Scudd. In these experiments the value of sawdust as a carrier for poison in bait mixtures was demonstrated under field conditions. In 1915, Circular No 5—"The Control of Locusts in Eastern Canada" was published and given wide publicity. For a number of years, the Cabbage Root maggot, *Hylemyia brassicae* Bouché was studied and the results published (1906) in Bulletin No 12, prepared jointly by the writer and Mr. R. C. Treherne. Since the appearance of this bulletin, frequent demonstrations have been given in the Ottawa district, proving the value of the corrosive sublimate remedy, which has now been widely adopted by commercial growers not only in Canada but also in the United States.

In 1919, an intensive study of the Colorado Potato beetle was planned by the writer and incepted at Ottawa, with the assistance of Mr. J. A. Flock. This study has been continued at Fredericton, N. B., by Mr. R. P. Gorham, and at Strathroy, Ont., by Mr. H. F. Hudson. Much valuable data have been obtained, which it is hoped to publish in the near future.

White grubs have also been investigated, life-history notes on the following species having been obtained: *Lachnosterna fusca* Froel., *L. anxia* Lec. and *L. drakei* Kby. In this work Mr. H. G. Crawford assisted.

The value of aerial surveys in forest insect investigations was demonstrated in 1920, when Dr. J. M. Swaine and Mr. M. B. Dunn made aeroplane flights in Spruce Budworm-infested districts in Northern Ontario, especially between Lakes Temiskaming and Temagami. In the same year two forest sample plots were established on the shores of Lake Abitibi.

The results of Dr. Swaine's studies of Canadian Bark-beetles were published in 1917 and 1918; Part 1, Descriptions of New Species-in the former year; and Part 2-A Preliminary Classification, with an account of the Habits and Means of Control, in the latter year. This publication of 143 pages, (Bulletin No. 14) has received widespread favour from entomologists and foresters. During recent years Dr. Swaine and Mr. Ralph Hopping have made special studies of groups in the family Cerambycidae and an important paper on the Lepturini of North America has been completed.

Mr. L. S. McLaine, Chief of the Division of Foreign Pests Suppression, has been accumulating, at Ottawa, an interesting collection of insects found on imported plant products. Largely through the efforts of Mr. R. C. Treherne, Chief of the Division of Field Crop and Garden Insects, "The Canadian Insect Pest Review" was established in April, 1923. This is a manuscript publication prepared especially for the information of federal workers. Mr. C. R. Twinn has assisted in the preparation of this review.

For several years the same Division has prepared statements on insect conditions for publication in the monthly "Fruit and Vegetable Crop Report" published by the federal Fruit Branch.

The Vineland laboratory which is in the main building of the Vineland Horticultural Station and has been under the continuous direction of Mr. W. A. Ross; an excellent insectary was erected in 1919. Mr. Ross during the past ten years has established a close connection with the growers of the Niagara Penninsula, and the result of the work undertaken has been of great value to the district. The life-histories of such important pests as the Pear Psylla, *Psyllia pyricola* Forst.; the Apple Maggot *Rhagoletis pomonella* Walsh.; the Potato Leaf-hopper, *Empoasca mali* Le B.; the Plum Spider Mite, *Paratetranychus pilosus* C. & F.; the Grape Leaf-hopper, *Erythroneura comes* Say;

the Rose Chafer, *Macrodactylus subspinosus* Fab.; the Black Cherry aphis, *Myzus cerasi* Fab.; the Strawberry Weevil, *Anthonomus signatus* Say; the Rose Midge, *Dasyneura rhodophaga* Coq.; the blackberry Leaf-miner, *Matallus bethunei* MacG., and others, have been worked out and improved methods of control established. Much extension work has also been conducted from this laboratory and demonstrations in spraying and dusting under commercial conditions have been given each year in a number of important sections. Mr. Ross has also devoted much time to a systematic study of the family Aphididae. In May, 1919, an illustrated bulletin on the Apple Maggot, prepared jointly by Prof. L. Caesar and Mr. Ross was published by the Ontario Department of Agriculture. At the Vineland laboratory, Mr. Ross has been assisted by Messrs. C. H. Curran, W. Robinson, W. P. Garlick and J. A. Hall.

During the absence on military service of Mr. H. F. Hudson, Mr. J. R. Gareau was placed in charge of the Strathroy laboratory, in 1915; his chief investigations related to white grubs. During the summers of 1916 and 1917, Mr. H. G. Crawford was employed temporarily at Strathroy to extend these investigations owing to the continued absence of Mr. Hudson. In 1918, the temporary portable laboratory at Strathroy, was replaced by a permanent structure, Mr. H. F. Hudson continuing in charge. At this laboratory field crop insects have been given special study. White grubs, *Lachnosterna* spp., as already mentioned, have received particular attention and the habits and life-histories of several important species have been worked out. Much new information has also been obtained on the Colorado Potato Beetle, *Leptinotarsa decemlineata* Say; the Hessian Fly, *Phytophaga destructor* Say; the Clover Leaf Weevil, *Hypera punctata* Fab.; the Army Worm, *Cirphis unipuncta* Haw., etc. Recently Mr. Hudson has also assisted in European Corn Borer studies in western Ontario. In 1914, there was a very severe outbreak of the Army Worm in Ontario, damage to the value of $250,000. being effected to growing crops. Mr. Hudson took a prominent part in the control campaign and, in co-operation with officials of the Ontario Department of Agriculture, rendered valuable aid in saving considerable acreages of crops. The trench method of control was the one specially demonstrated. An account of this work is published in Entomological Bulletin No 9, which appeared in 1915.

Following the discovery of the European Corn Borer, *Pyrausta nubilalis* Hbn., in 1920, by Messrs. Keenan and Simpson, a temporary field laboratory was established at Port Stanley in the spring of 1921, Mr. H. G. Crawford, of the Division of Field Crop and Garden insects being placed in charge. The scouting work conducted during the previous year by the Division of Foreign Pests Suppression in co-operation with the Provincial Department of Agriculture, revealed that seven counties were infested by the borer. In the latter year, biological investigations were incepted and methods of control studied. These studies are still being continued and much success has attended the efforts of our officers. In all of this work we have been closely associated with provincial officials and also with officers of the United States Bureau of Entomology. At the conclusion of the scouting work in 1923, 21 counties in Ontario were known to be infested, the important infestations, remaining, as in 1921, in Elgin and Middlesex counties and the Entomological Branch has maintained quarantines on all such counties. The Port Stanley laboratory has served as the headquarters for those engaged in scouting for the corn borer, Mr. W. N. Keenan having the immediate direction of this latter work, assisted by Messrs. L. J. Simpson and C. R. Twinn. In the biological and control investigations, Mr. Crawford has been assisted by Mr. R. H. Painter.

A temporary Corn Borer parasite laboratory was established at St, Thomas in 1923, with Mr. A. B. Baird in charge. In May of that year, a small breeding stock of the European parasite, *Habrobracon brevicornis* Wesm., was presented to us by the United States Bureau of Entomology. During the season fairly strong colonies of the parasite reared in the laboratory were liberated in important corn borer infested fields, over 600,000 individuals of the parasite being released altogether. Several native parasites which attacked the corn borer have also been under observation. In this work, Mr. Baird has been assisted by Mr. H. G. Dyce.

In 1922, a plant inspection office was established in the Customs Examining Warehouse, Toronto, Mr. W. A. Fowler in charge, and with the coming into effect of the revised regulations under the Destructive Insect and Pest Act, in Sept,. 1923, the fumigation stations at Niagara Falls and Windsor, were closed, but the station at Montrose was retained. In the same year, an inspection office was opened at Niagara Falls, Mr. R. W. Sheppard in charge, and an inspection service established at Windsor, Ont., Mr. C. S. Thompson in charge.

Provincial

The Provincial Entomologist, Prof. L. Caesar, has continued, since 1914, to direct the provincial entomological work, and his investigations have added very materially to the knowledge of several of our important insect pests.

Bulletins on such insects as the Cherry Fruit Fly, *Rhagoletis fausta* O. S., the Apple Maggot, *Rhagoletis pomonella* Walsh., and the Cabbage Maggot, *Hylemyia brassicae* Bouché, have been prepared by Prof. Caesar and these present original data both as regards the biology of the insects and their control. In addition to these publications the Department has continued to include in its Annual Reports notes on entomological work conducted under the direction of Prof. Caesar. Mr. A. H. McLennan, as the Ontario Vegetable Expert, conducted educational work, particularly in regard to the control of the Cabbage Maggot.

During the summer months, inspectors of the Department visit nurseries in Ontario, particularly in districts where the San José Scale is present. In 1920, 1921 and 1922 provincial inspectors also co-operated with the Dominion Entomological Branch in the Corn Borer scouting work in the Province of Ontario. For a number of years, too, the Department has assisted the federal Department in the inspection of imported nursery stock.

The Department continues to publish the Annual Reports of the Entomological Society of Ontario and also to grant to the Society, annually, the sum of $1,000.

Since the appearance of the European Corn Borer, in western Ontario, a laboratory has been established near Port Stanley, Ont., with Mr. G. J. Spencer in charge. At this laboratory the life-history of the Corn Borer and means of control have been studied. The whole problem in general has been investigated in close co-operation with the officials of the Dominion Entomological Branch and as a result of this co-operation a bulletin on the corn borer recently appeared under the authorship of Messrs. G. J. Spencer and H. G. Crawford.

Ontario Agricultural College

At the Ontario Agricultural College, the staff of the Entomological Department in 1914 consisted of Dr. C. J. S. Bethune, Professor of Entomo-

logy and Zoology; L. Caesar, Associate Professor; A. W. Baker, Lecturer and G. J. Spencer, Demonstrator. To-day it is comprises of : L. Caesar, Professor of Economic Entomology; A. W. Baker, Professor of Systematic Entomology and Zoology; G. J. Spencer, Lecturer, and J. A. Flock, Demonstrator. Dr. Bethune retired from active entomological work in 1921 ; no one in Canada has been more keenly interested in the development of applied entomology than he. His life has certainly been a most useful one and it is a great pleasure to us in Canada to know of the wide esteem in which he is held by entomologists the world over.

During the years covered by this review, many students at Guelph have decided upon entomology as their life's work. Some of these have accepted positions outside of Canada where they are making excellent reputations; others have entered federal or provincial services where they are establishing splendid records.

Professor Baker has made special studies of live stock insects and has also been much interested in the Mallophaga. In 1919, he studied the Mallophaga collected by the members of the Canadian Arctic Expedition (1913-1918), and this was published as Part D, of Volume III, on Insects.

Entomological Society of Ontario

This well known society has continued to aid to a marked degree the development of applied entomology in Canada. Since 1914, the Annual Reports of the Society have been published each year. These contain papers of considerable value. The parent society with headquarters at the Ontario Agricultural College has held series of winter meetings and these have been of special benefit to students attending the college. The branches of the society in Nova Scotia, Quebec and British Columbia, have also been active.

The Canadian Entomologist, published by the society has been issued regularly and with the close of 1923, Volume LV was completed.

University of Toronto

A course in forest entomology, has been given during recent years at the University of Toronto, by Professor E. M. Walker. Dr. Walker too, has continued his studies in Orthoptera, and Dr. W. A. Clemens, while attached to the University staff, made valuable investigations of ephemerid and other insects as a source of food for fishes.

MANITOBA

Federal

Mr. Norman Criddle has continued in charge of the work conducted from the laboratory at Treesbank. The original building erected in 1915, although small, was the home of much original research. In 1923, a larger permanent structure was erected. Mr. Criddle's investigations have related very largely to insects attacking grain crops. Studies of white grubs, begun in 1914, continued to occupy much of his time, and life-history data on the following species have been obtained: *Lachnosterna rugosa* Welsh, *L. anxia* Lec., *L nitida* Lec. and *L. drakei* Kby. The Western Wheat-stem sawfly, *Cephus cinctus* Nort. and the Hessian Fly, *Phytophaga destructor* Say, have been under special observation

for years, and in 1915 a bulletin discussing the habits and control of these two pests was published. A further pamphlet on the former insect was distributed in 1922 and one on the latter in 1923. In connection with studies of the Western Wheat Stem-sawfly, it was noted by our officers and also by provincial officers, that the larva of the sawfly does not cut the stems until the plants begin to lose their sap. The early cutting of grain, therefore, was recommended and this has meant savings amounting to many hundreds of thousands of dollars. In 1915, and later years, Mr. Criddle made large collections of the adults of the grass stem maggots,(Oscinidae) which were determined by Dr. J. M. Aldrich, of the United States Bureau of Entomology. Much valuable data were thus secured on the distribution of these insects. Several species of these flies were also reared from wheat, rye, corn and barley.

The recent outbreak of grasshoppers in the prairie provinces, was first investigated, in Manitoba, by Mr. Criddle, in 1919. The prevalent species were the Roadside Grasshopper, *Camnula pellucida* Scudd, and the Lesser Migratory Grasshopper, *Melanoplus atlanis* Riley. According to Mr. Criddle the outbreak in Manitoba was the worst of which he had record since 1875. The total area infested was more than 500,000 acres. Early in 1920, a circular entitled "Locust Control in the Prairie Provinces" was prepared by Mr. Criddle and given wide circulation. In this year, the infestation covered a wider area than that of 1919. In 1920, it was estimated that the co-operative efforts of provincial and federal entomologists resulted in the saving of crops worth $17,000.000. Experiments with poisoned baits consisting of sawdust of any kind mixed with an equal quantity of bran were entirely successful and considerably reduced the cost of control. A further reduction in the cost resulted from the use of salt as an attractant instead of the more expensive molasses and lemons. In 1921, Mr. Geo. E. Sanders, in charge of insecticide investigations, was detailed to Manitoba to assist in experimental work with poisoned baits, and a temporary laboratory was established at Souris. Much data regarding various attractants, etc., were obtained. This was a continuation of similar work undertaken in Saskatchewan in 1920. During the summers of 1920 and 1921, Mr. P. N. Vroom was transferred to Treesbank, to assist Mr. Criddle in grasshopper investigations.

Studies of various species of cutworms and other important field crop insects have also been made by Mr. Criddle as time permitted. Live stock and shade tree insects have also had his interest. During the last few years one of his assistants, Mr. H. A. Robertson, has undertaken a study of the mosquitoes of Manitoba.

Few serious outbreaks of forest insects have occurred in Manitoba during the last decade. The Larch Sawfly, *Lygaeonematus erichsonii* Hartig., has increased in numbers and in some sections has effected important injury. In 1922, Dr. Swaine studied an outbreak of the Destructive Spruce Bark-beetle, *Dendroctonus piceaperda* Hopk., affecting white spruce, in the province.

Parasitized cocoons of the Larch Sawfly imported from England, by the late Dr. Hewitt, were distributed in larch stands in Manitoba in 1912 and 1913, east of Cedar Lake and near Aweme. In the spring of 1916, Mr. Criddle visited the latter area and from a collection of 514 cocoons, reared 27 specimens of the European parasite *Mesoleius tenthredinis* Morley, thus indicating that the species had become established in that locality.

With the coming into effect of the revised regulations under the Destructive Insect and Pest Act, in Sept. 1923, the fumigation station at Winnipeg was closed.

Provincial

Under the direction of Mr. J. H. Evans, Deputy Minister of Agriculture, the Department has been actively engaged in an important grasshopper campaign during recent years as a result of which millions of dollars worth of crops have been saved to the farmers. In this connection, Mr. A. V. Mitchener has given me the following notes: "In a province where federal and provincial officers have worked as harmoniously as they have in Manitoba, it is impossible and undesirable to ascribe entire credit for any achievement to provincial authorities. The local Department of Agriculture possibly inaugurated one of the first wholesale campaigns against grasshoppers put on in Canada. The successful issue of this campaign was largely made possible through the effort of the federal entomological field officer, Mr. Norman Criddle, whose suggested changes in the bait used, very materially lessened the cost of the campaign. In this campaign a homemade machine for mixing grasshopper baits in large quantities was developed and was given the name of the "Manitoba Mixer". The Department of Agriculture, in co-operation with the Dominion Entomological Branch, has also conducted important work in connection with investigations relating to the control of the Western Wheat Stem-sawfly Recommendations that wheat be cut early to avoid loss from sawfly injury has saved many thousand of bushels of wheat for the farmers."

On March 27, 1920, "An Act to Amend 'The Municipal Act' was assented to (Chapter 82 of 10 George V, Statutes of Manitoba). This Act included the following regarding grasshoppers: "The council of a municipality may, by resolution supported by two-thirds of its members, institute measures for the destruction and control of grasshoppers or other insect pests injurious to crops, and may vote out of the general revenue of the municipality such sum or sums as may be required for the purpose."

Manitoba Agricultural College

In the province of Manitoba previous to 1918, instruction in entomology at the Manitoba Agricultural College was given by Professor F. W. Broderick and Mr. J. A. Neilson of the Department of Horticulture. In May, 1918, Mr. A. V. Mitchener was appointed lecturer in Entomology, but his title has since been changed to Assistant Professor of Entomology.

Natural History Society of Manitoba

This society has of recent years been devoting considerable attention through its Entomological Section to the study of insects, chiefly under the leadership of Mr. J. B. Wallis. The society has published a "Key to Manitoba Butterflies", by Mr. Wallis, and Messrs. Criddle and Wallis have in preparation a "List of Manitoba Coleoptera."

SASKATCHEWAN

Federal

In 1918, through the courtesy of President Murray of the University of Saskatchewan, Saskatoon, accommodation was granted for the establishment of a Dominion entomological laboratory, and Dr. A. E. Cameron was appointed

entomologist-in-charge. During the previous year, Dr. Cameron in co-operation with Dr. S. Hadwen, then pathologist of the federal Health of Animals Branch, incepted a joint study of the bot fliesaffecting horses, the results of which were published in *The Bulletin of Entomological Research*, Vol. IX, No. 2, 1918. In the same year, Dr. Cameron began studies of other blood-sucking diptera, such as mosquitoes, tabanids and black flies. In 1918, too, a remarkable outbreak of the Sugar-beet Webworm, *Loxostege sticticalis* Linn., occurred in the Prairie provinces, particularly in Saskatchewan where millions of migrating larvae caused widespread alarm. The outbreak of grasshoppers (*Camnula pellucida* Scudd, and *Melanoplus atlanis* Riley), in 1919, which involved an area of approximately 1500 square miles, was investigated by Dr. Cameron and Mr. M. P. Tullis, of the Provincial Department of Agriculture. This outbreak is discussed in Entomological Circular No 13. In the following year the province was again subjected to a serious grasshopper infestation and, as I mentioned in my annual report for the two years ending March, 1921, in regard to poisoned bait, "sawdust was employed to a considerable extent. To the Entomological Branch belongs the credit of first demonstrating under large acreage conditions the value of sawdust as a cheap carrier for poison." In this year (1920), Mr. A. Kelsall (Insecticide Investigations) spent the greater part of the months of June and July in the neighborhood of Carlyle, Sask., in order to investigate further the value of various poisons for killing grasshoppers and dust mixtures, contact sprays, poison gas and poisoned baits were experimented with. A brief account of this work is given in the report referred to above. Officers of the Branch have kept in close touch with provincial officers during the whole of the recent grasshopper campaign.

Dr. Cameron's permanent appointment with the Branch terminated in October, 1920, but in the summer of 1921, pending the appointment of a successor, he was re-employed at Saskatoon. Mr. K. M. King was appointed in August, 1922, as entomologist in charge of the laboratory. Since his appointment he has been specially interested in soil-infesting insects, particularly cutworms and wireworms. In 1923, he incepted a series of soil faunal studies in co-operation with the Departments of Field Husbandry and Physics of the University of Saskatchewan. In the same year, an outbreak of the North-West Chinch Bug, *Blissus occiduus* Barber, closely allied to the true Chinch Bug, was investigated by Mr. King in the vicinity of Lacadena.

Previous to the establishment of a permanent laboratory at Saskatoon, Mr. Norman Criddle, in charge of the Treesbank, Man., laboratory, assisted materially in entomological investigations in the province. In 1915, he studied the outbreak of the Red-backed Cutworm, *Euxoa ochrogaster* Gn., which infested territory extending from Selkirk in Manitoba to Fort Pitte and Lloydminster on the western boundary of Saskatchewan. In the vicinity of Wadena, Sask., it was estimated that 3,000 acres of crop were damaged, of which 1750 acres were totally destroyed. In 1916, Mr. Criddle noted the spread of the Western Wheat-stem Sawfly into that portion of Saskatchewan adjoining the south western region of Manitoba.

The Division of Forest Insects have investigated outbreaks of forest insects particularly in Northern Saskatchewan. In 1922, Dr. Swaine visited the spruce areas along the lower Saskatchewan river and on the Porcupine Forest Reserve. Extensive outbreaks of the Destructive Spruce Bark-beetle, *Dendroctonus piceaperda* Hopk., were investigated and the Larch Sawfly was noted to be increasing in the areas visited. In 1923,Mr. Norman Criddle,

investigated a rather serious outbreak of one of the tent caterpillars, (*Malacosoma* sp.) particularly on the Moose Mountain Reserve, where aspen poplars, especially, were defoliated. In the same year, Mr. J. J. de Gryse was appointed to take charge of shade tree insect investigations in the Prairie Provinces and with the interest and co-operation of Mr. Norman M. Ross, Chief of Tree-planting Division, Dominion Forestry Branch, a temporary laboratory was established on the Forestry Station at Indian Head. Mr. de Gryse, visited also, later in the year, the Moose Mountain area infested by tent caterpillars. An excellent start has been made in shade tree insect investigations and Mr. de Gryse has already accumulated much data of value.

With the coming into effect of the revised regulations of the Destructive Insect and Pest Act, Sept. 1, 1923, the fumigation station at North Portal was closed.

Provincial

During the last decade, Mr. M. P. Tullis, Field Crops Commissioner, has aided very materially in entomological control work in the province and he has been chiefly responsible for the recent very successful grasshopper campaign The following quotation is from his report for 1923. "In 1919, forty-six rural municipalities were infested. Unfortunately, 90,000 acres of crop were destroyed, but as a direct result of the campaign 120,000 acres were saved. In 1920, the outbreak was more serious, and ninety-seven rural municipalities were involved. However, the campaign was more highly organized and 1,400,000 acres of infested crop were saved, while only 45,000 acres were destroyed. In 1921, the same methods of organization were employed, and ninety-five rural municipalities fought the grasshoppers. 1,960,000 acres of infested crop were saved and 93,000 acres destroyed. In 1922, one hundred and thirty-seven rural municipalities were affected; 640,000 acres were saved and 23,000 acres destroyed.

Reviewing the situation during the last four years it is found that grasshoppers have cost the sum of $742,535.35 in supplies alone, assuming that in 1919 the municipalities paid out a sum equal to that spent by this Branch. The total number of acres of infested crop saved in the four campaigns is 3,256,000, and the acreage destroyed is 251,000."

University of Saskatchewan

With the appointment of Dr. A. E. Cameron, of the Dominion Entomological Branch, as Professor of Zoology and Entomology in 1920, the University took a more active interest in entomological research and education. In the University courses of instruction, Dr. Cameron has given the entomological lectures and directed the laboratory work. He has also continued his research work particularly in the dipterous family Simuliidae. In 1923, Dr. Seymour Hadwen, lately of the federal service, Ottawa, was appointed Research Professor of Animal Pathology. Dr. Hadwen is continuing entomological work, his interest being largely in insects affecting live stock before taking up his duties at Saskatoon, he prepared a bulletin concerning which, which was published by the Dominion Entomological Branch.

ALBERTA

Federal

The Entomological Branch laboratory at Lethbridge, established in 1913, was closed during 1917 and 1918, owing to Mr. E. H. Strickland's absence in Europe on military service. With Mr. Strickland's return to Canada, the laboratory was again placed under his charge in 1919, and 1920, and during the winter months, at Ottawa, he undertook studies of stored product pests. In March, 1921, Mr. H. L. Seamans, was appointed entomologist at Lethbridge.

In 1915, a new permanent laboratory was erected on the Dominion Experimental Station and adjoining space furnished for experimental purposes. The intensive study of the life-habits and control of the Pale Western Cutworm, *Porosagrotis orthogonia* Morr., incepted by the writer in 1913, in association with Mr. Strickland has continued to be the major project at the Lethbridge laboratory. The information gained by Messrs Strickland and Seamans has been of great value in infested districts.

In 1915, the first extensive outbreak in Canada of the Army Cutworm, *Chorizagrotis auxiliaris* Grt., occurred in Alberta covering an area of about 3,000 square miles. A bulletin giving the results of Mr. Strickland's researches was published in 1916. In the same year an entomological survey was made in the Lesser Slave Lake region in Northern Alberta by Messrs. Swaine and Strickland and important data obtained particularly on forest and field crop insects.

The 1919 outbreak of grasshoppers to which reference has been made under the provinces of Manitoba and Saskatchewan, was also serious in Alberta, particularly in areas west and south of Lethbridge. Mr. Strickland continued to direct the grasshopper campaign in 1920 and as a result of his work, crops to the value of over one million dollars were saved to farmers who followed our recommendations. Since 1920, the control of grasshoppers has continued to occupy much of the time of our officers. A study of alfalfa insects has also been incepted. The Alfalfa Thrips, *Frankliniella occidentalis* Pergande, in 1921, destroyed 80% of the buds of alfalfa. Mr. Seamans' studies have shown that an early "clipping" of alfalfa late in May will check the development of the insect to a material extent. In all of the work at the Lethbridge laboratory, we have had the close co-operation of Mr. W. H. Fairfield, Superintendent of the Experimental Station.

During his engagement, Mr. Strickland conducted important researches in the biology of parasites of prairie cutworms, much of the results of which have appeared in Entomological Bulletin No. 22 entitled "Biological Notes on Parasites of Prairie Cutworms."

In 1916, the late Dr. Hewitt spent most of the month of July, at Banff, Alta, for the purpose of investigating the problem of mosquito control within the district. From collections and rearings made, much valuable information was obtained, which constituted the foundation for further intensive work undertaken in 1922. In 1921, Mr. Eric Hearle and the writer made a survey of the important breeding places, and in the following year, in close-co-operation with the Dominion Parks Branch, a temporary laboratory was erected in the Rocky Mountains Park, with Mr. Hearle in charge. As a result of the control work conducted in 1922 and 1923, there has been a marked decrease in the numbers of mosquitoes present during the tourist season. Previous to 1922,

Mr. N. B. Sanson, Curator of the Banff Museum, had conducted some control work but little biological work had been attempted.

As this latter museum, Mr. Sanson has brought together a general collection of the insects of the Rocky Mountains Park.

In 1915, Dr. Swaine of the Division of Forest Insects visited the Lesser Slave Lake region in northern Alberta, for the purpose of investigating forest insect injuries. Infestations of the Destructive Spruce Bark-beetle, *Dendroctonus piceaperda* Hopk., and the Western Balsam Bark-beetle, *Dryocoetes confusus* Sw., were located. In the same year the valuable forests of the Rocky Mountains Park, Banff, were examined with a view to furnishing advice on their protection. Special studies of forest insect injury, particularly to pine, were made in 1919, by Dr. Swaine in the Jasper National Park. The trees showed characteristic evidence of mistletoe attack followed by various species of *Ips*. In 1923, the Division of Forest Insects, reported that the Larch Sawfly had defoliated larch trees west of Edmonton. Correspondents of the Branch also reported injury in sections north and west of Edmonton.

During the summers of 1922 and 1923, the Division of Foreign Pests Suppression undertook scouting for the Alfalfa Weevil, *Phytonomus posticus* Gyll in southern Alberta. In 1922, 286 farms were visited and a large number of sweepings made from fields of alfalfa. During the following year (1923), 491 farms were visited and sweepings made from 542 fields of alfalfa. As yet no sign of the Alfalfa Weevil has been discovered in western Canada.

Natural control studies particularly of the Fall Webworm, *Hyphantria cunea* Dru., and the Tent Caterpillar, *Malacosoma disstria* Hbn., were made in British Columbia and Alberta in 1917 and 1918 by Messrs Tothill and Baird. In the latter year, Mr. Baird spent about six weeks in the neighborhood of Sylvan Lake.

In October, 1923, the Entomological Branch was allotted two rooms in the Post Office Building in Lethbridge. These will be used for laboratory purposes especially during the winter months.

Provincial

No official with the title of Provincial Entomologist has so far been appointed. Mr. Donald Mackie of the Department of Agriculture conducted entomological correspondence for a number of years and gave advice regarding the more common insect pests of the province. During recent years particularly in connection with the grasshopper campaign, Professor E. H. Strickland of the University of Alberta, Mr. H. A. Craig, Deputy Minister and Mr. Z. W. MacIlmoyle, Assistant Deputy Minister, of the Department, have rendered much assistance to the farmers in insect control work.

In 1922, the province passed "An Act to provide for the Extermination of Agricultural Pests." This legislation gave the Department of Agriculture power to take such action as it thought desirable in the control of pests of grain or other crops and a separate part of the Act dealt particularly with grasshopper control. In 1921, a circular on grasshopper control prepared by Messrs. Strickland and Seamans was published by the Department.

University of Alberta

Mr. E. H. Strickland of the Dominion Entomological Branch was appointed in 1922, to the newly created position of Professor of Entomology in the

University and since then he has, in addition to teaching entomology, endeavoured to build up a working collection of the insects of the province and also a general consulting library. In his new field of labour he has already made interesting progress and in economic problems of importance has continued to aid federal work in addition to directing provincial activities.

The Alberta Natural History Society.

Since 1914, this society has continued to publish in the Annual Report of the Department of Agriculture a statement regarding insects of the season. This report has in the main been prepared by Mr F. C. Whitehouse. In addition to this annual statement the society has published the following important lists: "Dragonflies (Odonata) of Alberta, by F. C. Whitehouse, issued May, 1918; "Annotated Check List of the Macrolepidoptera of Alberta", by K. Bowman, issued February, 1919, and "Annotated List of Coleoptera of Northern Alberta", by F. C. Carr, issued August, 1920.

BRITISH COLUMBIA

Federal

In 1914, the Entomological Branch had its headquarters in the Province of British Columbia, at Agassiz, with Mr. R. C. Treherne in charge. In that year investigations chiefly related to root maggots, wheat midge and insects affecting fruit particularly in the Lower Fraser and Okanagan Valleys. Bulletin No. 8, on the Strawberry-root Weevil, by Mr. Treherne was published in 1914, and in the same year Bulletin No. 7 on "Forest Insect Conditions in British Columbia", by Dr. Swaine, was also published. In 1914, too, a temporary forest insect laboratory was established in Stanley Park, Vancouver, with Mr. R. N. Chrystal in charge. Spruce gall aphids, the Hemlock Looper, (*Ellopia* sp.) and bark-beetles were especially investigated. In 1915, this work was continued, and in the same year, Dr. Swaine visited the National Parks at Glacier and Field to examine forest insect prevalence. The Stanley Park laboratory was closed in 1917, when Mr. Chrystal returned to Ottawa to undertake studies of scale insects in general and also certain shade tree insects.

The Cabbage Root Maggot project engaged most of Mr Treherne's time, in 1915, at Agassiz, and much valuable work was accomplished. In view of the discovery of the Pear Thrips *Taeniothrips inconsequens* Uzel. a temporary laboratory was established in 1916 at Royal Oak, Dr A. E. Cameron appointed in that year being specially detailed to carry on the investigation with the co-operation of Mr. Treherne. In this work our officers had the assistance of Mr. E. V. White of the Provincial Horticultural Branch. The results of this study which was continued in 1917, were published in Bulletin No 15. In 1916, too, a study of the Codling Moth situation in the province was begun by Mr Treherne with the assistance of Mr M. Ruhmann of the provincial service. In this year, Bulletin No. 12 on the "Cabbage Root Maggot and its Control in Canada" was prepared jointly by the writer and Mr. Treherne. In experiments for destroying insects affecting stored products conducted in 1917, the value of heat was demonstrated in the province for the first time. In that year, in addition, the life-history and control of the Peach Twig Borer,

Anarsia lineatella Zell., were studied by Mr. Treherne, as a result of which, as stated in the report of the Dominion Entomologist for 1917 and 1918, "the spraying of peach and apricot orchards with lime sulphur and arsenate of lead, the pre-blossom spray with lime-sulphur being emphasized, was enforced by the Provincial Department of Agriculture."

In 1918, the federal provincial headquarters were moved from Agassiz to Vernon. Here Mr. Treherne continued Codling Moth and other important fruit insect studies. In this year, a laboratory was established at Victoria, with Mr. W. Downes in charge. From this laboratory investigations relating particularly to insects affecting strawberries and other small fruits were conducted. The Strawberry root-weevil, *Brachyrhinus ovatus* Linn. was specially studied by Mr. Downes and observations on this insect have been continued since. The value of barriers for protecting crops from the weevil has been demonstrated under commercial conditions as explained in Pamphlet No 5, N. S., published in 1922. The Agassiz laboratory was in charge of Mr. A. B. Baird from 1917 to 1920 inclusive. Since then Mr. R. Glendenning has been in charge.

Studies of several lepidopterous insects affecting the apple were continued by Mr. Treherne in 1919. In this year the provincial and federal activities were co-ordinated, Mr. Treherne assuming the general direction of the work. Outbreaks of the Roadside Grasshopper, *Camnula pellucida* Scudd., in the Bridesville-Rock Creek area and in the Chilcoten district; the Lesser Migratory Grasshopper, *Melanoplus atlanis* Riley, at Celesta; and the Red-legged Grasshopper, *Melanoplus femur-rubrum* DeG. in the Fraser Valley, were investigated. In 1920, special studies were undertaken in the Chilcotin district by Mr. E. R. Buckell of the provincial service, under the direction of Mr. Treherne. Studies of the life-history and control of the Imported Onion Maggot, *Hylemyia antiqua* Mg., which had been in progress for several years were continued in the Okanagan Valley in 1919, 1920 and 1921 by our officers in association with Mr. M. Ruhmann of the provincial service, and in the latter two years important demonstrations further emphasized the value of the corrosive sublimate remedy for the Cabbage Maggot, *Hylemyia brassicae* Bouché. In 1920, Mr. Treherne continued studies of insects affecting the apple and biological notes were made on *Mineola tricolorella* Grt., *Rachela bruceata* Hulst, *Epicallima dimidiella* Wlshm., *Peronea maximana*, Busck, and *Cacoecia rosaceana* Harr., etc. Experiments in the superheating of refrigerator cars for the destruction of larvae, such as those of the Codling Moth, were also incepted with the assistance of the Provincial Horticultural Branch.

In 1921, Mr. Treherne was promoted to the position of Chief, Division of Field Crop and Garden Insects, with headquarters at Ottawa. During his absence from Vernon, the work has been carried on largely under his continued direction with Mr. E. P. Venables assisting locally. This latter officer has from 1921 to date conducted further work on the life-history and control of apple insects. The Fruit-tree Leaf-roller, *Cacoecia argyrospila* Walk., caused noticeable injury in the Okanagan Valley in 1922 and studies of the same were at once begun. These have required the major portion of Mr. Venables' time. In 1920, an important infestation of the Satin Moth of Europe, *Stilpnotia salicis* Linn., was discovered by Messrs. Tothill and Baird in the city of New Westminster. Mr. R. Glendenning was instructed to make a detailed study of the insect and this occupied most of his time in 1921, since when he has continued to make observations each year. A full report on this work is being prepared. The insect has now spread to Vancouver Island. Other insects which have been

specially investigated by Mr. Glendenning from the Agassiz laboratory are *Bembecia marginata* Harr., *Phorbia rubivora* Coq., *Epochra canadensis* Loew., *Psylliodes punctulata* Mels., *Epitrix cucumeris* Harr., *Phyllotreta albionica* Lec. and *Eriosoma ulmi* Linn.

At the Victoria laboratory, Mr. Downes has made excellent progress in the study of small fruit insects. During recent years he has also investigated the life-history and control of the Poplar Sawfly, *Trichiocampus vimimalis* Fallen; the leaf-roller, *Cacoecia rosana* L.; and two insects affecting holly, namely *Proteopteryx ilicifoliana* Kearf., and *Phytomyza ilicis* Curtis. In addition, too, he has made systematic studies in the Hemiptera. In 1922. Mr. E. R Buckell was appointed to the federal service. In that year a serious out break. of grasshoppers occurred in the range sections of the Nicola Valley and a temporary laboratory was established at Nicola, in charge of Mr. Buckell, with Mr. P. N. Vroom assisting.

In 1913, a study of the biology and control of bark-beetles was incepted in British Columbia. Control operations on an extensive scale were begun during the winter of 1918-1919 in the Coldwater, Spious, and adjacent valleys, in co-operation with the Provincial and Dominion Forestry Branches. This work has been under the immediate direction of Mr. Ralph Hopping appointed to our service in 1919. Surveys previously made by Dr. Swaine had shown that the Mountain Pine beetle, *Dendroctonus monticolae* Hopk., and the Western Pine beetle, *Dendroctonus brevicomis* Lec., had destroyed millions of dollars worth of yellow pine. With the adoption of control measures, yellow pine trees worth more than six millions of dollars were saved from destruction up to 1922. This bark-beetle control work has given definite and most satisfactory results. It is undoubtedly one of the outstanding examples of such control work yet undertaken. Throughout this whole investigation Dr. Swaine has been closely associated with Mr. Hopping. Outbreaks of the Mountain Pine beetle in lodgepole pine and western white pine and of the Douglas Fir beetle, *Dendroctonus pseudosugae* Hopk., have also been studied and control operations established. In 1921, the Branch published Circular No. 15. "The Control of Bark-beetle outbreaks in British Columbia," by Mr. Hopping. In this year a rather remarkable outbreak of the tussock moth, *Hemerocampa pseudotsugata* McD., occurred in Vernon and adjacent neighborhoods. Injury by this insect in 1917, at Hedley, B. C., and in 1918, at Chase B. C. had previously been recorded, by Mr W. B. Anderson, in *The Agricultural Gazette of Canada*, Vol. 6, 139, under the name of *Hemerocampa vetusta gulosa* Hy. Edit. During the years covered by this review, Dr. Swaine has made several forest insect surveys in a number of sections of British Columbia as a result of which it has been possible to develop control recommendations of considerable value.

A laboratory for mosquito investigations, was established at Mission, B. C., in 1919, with Mr. Eric Hearle, in charge. During this year, a faunal survey of many of the breeding areas in the Fraser Valley was undertaken, and much valuable data assembled. During 1920, the mosquito plague was, next to the actual loss of crop from the flooding of the Fraser river, the most vital economic factor affecting the lower portion of the valley. Nearly all the lumber camps in the affected district were closed down for varying periods, construction of roads was hampered and general farming and horticultural interests seriously handicapped. These investigations were continued in 1920 and 1921. In the latter year with the co-operation of the Air Board,

observation flights were made by Mr. Hearle and photographs taken of the important breeding areas.

Natural control studies, particularly of tent caterpillars, Spruce Budworm and Fall Webworm were begun in British Columbia in 1917, when Dr. Tothill, in charge of such investigations, visited Vancouver Island and other districts. The results of the Fall Webworm studies (1917-1919) are published in Entomological Bulletin No. 19. In 1918, Mr. A. B. Baird, continued these investigations, making his headquarters at the Agassiz laboratory. In the former year (1917) Dr. Tothill liberated colonies of the predaceous mite, *Hemisarcoptes malus* Shimer, collected in eastern Canada, at several places in British Columbia where the Oyster Shell Scale, *Lepidosaphes ulmi* L. was prevalent. Observations made every year since, have indicated that the mite has become well established and is spreading its range. Mr. Baird remained in British Columbia to continue natural control studies until the autumn of 1920 when he returned to the Fredericton laboratory. In 1920, Dr. Tothill visited British Columbia for the purpose of making special studies in connection with the natural control of the Spruce Budworm. The presence of parasites, the value of certain birds, the effect of wind dispersal and other factors were investigated.

The fumigation station at Vancouver erected in 1900 was closed in 1923 and in the same year a modern fumigation and inspection station was erected in the yards of the Canadian National Railway. The new station was built jointly by the Dominion and Provincial Departments of Agriculture.

The work in the Indian orchards in British Columbia which was conducted by the late Mr. Tom Wilson until he met his death in the burning of the Coquihalla, Hotel, at Hope, B. C. in March, 1917, and since by Mr. W. B. Anderson appointed in the spring of 1918, has resulted in much good. The Indians of the various reserves have been informed as to the remedies for the common pests of the orchard, field, and garden ,and demonstrations have been conducted in spraying and other methods of insect control. By working closely with the Indians of the province, both the late Mr. Wilson and Mr. Anderson have made excellent progress. This work, which is under the direction of the Dominion Entomologist, is financed by the federal Department of Indian Affairs.

Provincial

In British Columbia important provincial developments have taken place, particularly in regard to the inspection of plant products entering the province. The province has long had an enviable record in such endeavors and its comparative freedom from many important pests prevalent elsewhere, is undoubtedly due to the wisdom of the late Mr Thomas Cunningham who had charge of such work up to the time of his death in February, 1921. Since this date, the work has been under the direction of Mr W. H. Lyne.
During 1923, the Provincial Department of Agriculture and the Federal Department of Agriculture jointly erected a modern building which will be devoted to the inspection of nursery stock, etc., and the fumigation of plants or other products as may be necessary. In 1914, Mr. J. W. Eastham succeeded Mr W. H. Brittain, as Provincial Entomologist and Plant Pathologist, with Mr M. Ruhmann as assistant in entomology. These officers are still in the employ of the province. In 1918, Mr. E. R. Buckell was appointed as a provincial officer and was detailed at first to Codling Moth eradication work and later to investigations relating to insects affecting range and cereal crops. In 1921, a temporary laboratory was established in the Chilcotin district, with

Mr. Buckell, in charge for the purpose of investigating the species of grasshoppers present on the range lands. Life-history and ecological notes were made on about 40 species of grasshoppers common to range areas.

The Horticultural Branch have published a number of entomological circulars, which with few exceptions were prepared by Mr. Treherne. These are on such subjects as, The Cabbage Root Maggot; The Strawberry Weevil; The Currant Gall Mite; The Onion Thrips; The Woolly Aphid of the Apple; The Imported Cabbage Worm; The Lesser Apple worm; The Oyster-shell scale; The Peach-twig Borer; Locust Control, etc.

During recent years, additional legislation concerning the control of the Codling Moth and timber-infesting insects has been passed by the provincial government.

University of British Columbia

At the University of British Columbia, entomology, has received attention, especially during recent years, lectures dealing with insects having been given by Dr. C. McLean Fraser, Mr. R. C. Treherne and Mr. F. C. Auden

The Entomological Society of British Columbia

Since 1914, this society has continued to publish its valuable Proceedings. In 1916 and later, the society has published separately the systematic and economic papers. These Proceedings have added very materially to our knowledge of the insects of British Columbia.

Report of the Provincial Museum of Natural History

In these annual reports, a number of valuable entomological papers have appeared, particularly by Mr. E. H. Blackmore. A new check list of the lepidoptera of the province is being prepared by Mr. Blackmore. Through his contributions he has added materially to the knowledge of British Columbian insects.

CONCLUSION

I cannot close this paper without paying further tribute to those Canadian entomologists whom death called during the period covered by this review: Fyles Saunders Hewitt, Lyman, Sladen, Heath, Harrington, Reed, Cunningham, Wilson, Woolly-Dod—men, all of whom left their mark in the field in which they were specially engaged. Notices regarding their work have been duly published particularly in *The Canadian Entomologist.* The list is truly a formidable one and the loss to Canada has indeed been great.

MILLARDET

THE CREATOR OF APPLIED PHYTOPATHOLOGY

Prof. Georges Maheux, Provincial Entomologist, Quebec.

Close to the green-houses of the large botanical garden of Bordeaux, in the shade of splendid foliation and beautiful trees, a monument of plain sobriety and beautiful lines is erected. Vine branches loaded with grapes wind up the while stela of white stones; a beautiful nymph, symbolyzing viticulture, offers a bunch of grapes as homage to a bust of considerable size crowning the whole. The visitor charmed, stops before this magnificent sight which results from the perfect harmonization of the art of man with the art of nature. He approaches, in search of precisions to learn from the inscriptions, the name of the hero in whose memory, this imperishable memorial has been erected.

It is the monument raised through the gratefulness of the French and Foreign vine-growers, to the memory of Alexis Millardet and solemnly dedicated on the 15th of July, 1914, in the midst of a considerable concourse of officials, learned men, vine-growers, a few days before the declaration of the Great War. Verily, the erection of this monument was evident proof that the name and works of Millardet are always vivid in the minds of vine-growers of all the universe; his memory is the object of special worship among the proprietors of vine-yards of the southwest of France and of the Department of Grenoble. In fact, Millardet is considered as the saviour of French viticulture and it is as such that his admirers wished to immortalize in stone and bronze his name and features.

Millardet is not unknown among us. Our phytopathologists are of one common accord in giving him the name of the founder of experimental and applied phytopathology; and most of those who occupy themselves with the problems attached to the protection of plants know that his name is closely allied to the anticryptogamic preparation of almost universal use known under the name of Bordeaux Mixture. Indeed, if Millardet was not the exclusive inventor of this marvellous fungicide, he has the merit of having discovered its properties, of having perfected it, of having determined the definite formula and of having propagated its use in all the vineyards. A continued and severe test of forty years has shown beyond all doubt the value of this discovery and the merit of the discoverer.

Born in the Jura, at Monyminey, the 13th of December, 1838, of a distinguished family, Millardet first initiated himself into scientific life at the University of Paris where he studied medicine. His uncle also a physician, was destining him a very alluring estate and clientele. In spite of this alluring reality the young physician, for long drawn towards botany, decided to abandon his profession and to give himself up entirely to his favorite study.

At that time, the teachings and discoveries of a few German botanists were attracting to their chairs the young students of Europe. Millardet also went to Germany to study pure and applied botany with Hofmeister, at Heidelburg, and de Bary at Frielburg. Under the direction of these learned professors, he initiated himself into the art of hybridization which was then assuming considerable development, and plant pathology which was then beginning to give up its secrets.

Returning to France, Millardet obtained from the Sorbonne his degrees of Doctor of Medicine and of Sciences. Still a young man (1869) he became Professor of botany at the Faculty of Science of Strassburg. After the Franco-Prussian war, his former Professor, de Bary, was to succeed him at the professorship of Strassburg and he became Professor of botany at Nancy. It was there that the Academy of Sciences found him in 1876, at the time of the crisis of destruction of the magnificent vineyards of the south of France.

The prosperity of the vine-growing region was dangerously menaced by the Phylloxera, a redoutable insect the multiplication of which was rendering sterile and was ruining the vine yards of France where it elected domicile. As every one knowns, this insect had been imported into France with American vines, and as early as 1862 its presence was discovered. Its ravages at first insignificant increased with the number of its legions, so much that fifteen years later, the officials and savants were moved and resolved to act without delay. The Academy of Sciences took in hand the fight against the invader and delegated to Bordeaux Alexis Millardet as professor of botany with mission to study the ravages and to discover means of combating it. From now on this region will be the field of action of the botanist and phytopathologist; he will occupy for twenty seven years (1872-1899) this post, which he will abandon but three years before his death, in 1902.

Up to that time Millardet had been noted for his researches in pure botany and had thus won a high reputation. On his arrival at Bordeaux his whole time is given to the task of saving the vine, and, by his persevering works, guided by a tested and enlightened science, by an acute sense of observation, saves viticulture from ruin. Without losing time with measures of doubtful efficacy he is searching for a somewhat permanent means of struggle and by this conception of the application he is closely related to Pasteur, the savior of sericulture.

His patient researches permitted him to establish the scale of resistance of the said vines. But this resistance is only partial. Millardet then attempts to guard against this insufficiency by practising hybridization of the types both fecund and resisting. He opened the way to hybridization, showed its technic and created types that have rendered and still render the greatest services to vine-growers.

This first enemy checked, a second raised its head in 1878 and in its turn ravaged the vineyards; it was mildew. From work undertaken by Millardet,

after a deep study of the fatal fungus was born the Bordeaux Mixture of which he became the zealous and incessant propagator.

No one is ignorant that copper is the preservative, the active element of this mixture; it acts as preservative agent by creating on the surface of the exterior organs of the plants a deleterious medium to the development of the organisms of mildew. We cannot, in all justice, attribute to Millardet the merit of this discovery. In 1807, in a note on the rust of cereals, Benedict Prevost, pointed out the unfavorable action of sulphate of copper on the germs of rust, and recommended very weak solutions, namely 1 part of sulphate of copper to 400,000 parts of water. While very remarkable for the time, the note of Benedict Prevost had no sequence.

The appearance of mildew of the vine, well known in the United States since 1824, was to again give it value. Planchon, to whom a monument is erected at Montpellier, in the valley of the Garonne, first discovered the disease.

Several years elapsed before the anticryptogamic specific was adapted and propagated. It was during this period of groping that Millardet, aided by eminent collaborators like U. Gayon, in the laboratory, and M. Bouisset in the vineyards fixed the proportion of the various ingredients entering into the composition of the cupric mixture, now called Bordeaux mixture, from the place of its origin. The wine-growers commenced to employ this preservative in 1885 and Millardet did not spare his efforts to facilitate the rapid extension of the treatment against mildew.

It may be easily imagined that the formula now known only became such after numerous alterations. The first formulas proposed contained a considerable quantity of sulphate of copper. Millardet himself advised 15% of lime and 8% of copper; others even went up to 12% of salts of copper. Thick mixtures were the result (which well merited the name of mixture), difficult to spread. The actual formulas for ordinary treatment do not exceed 2% of sulphate of copper.

Millardet has also explained the action of Bordeaux mixture on mildew of the vine, by suggesting that the cupric solution acts on the spores of certain cryptogamia that it comes into contract with by preventing their germination. This theory applies as well to several other diseases, as may be judged by the popularity Bordeaux mixture has had for nearly forty years. There are hardly any horticultural products for which the use of this fungicide is not recommended as a preservative from numerous diseases. Of course the action of the preparation is not the same towards all of these parasites; but the unanimity of the phytopathologists in its favor is an evident proof of its intrinsic merits.

In Canada, professor Craig was one of the first, if not the first horticulturist to make use of Bordeaux mixture and to recommend its use, about 1895. It has made its way since then and is still largely in use throughout the whole country, principally for potatoes and other vegetables.

Among the publications of Alexis Millardet are to be specially remarked: "Le Prothalle male des cryptogames vasculaires" (1869) and "La Question des Vignes Américaines au point de vue théorique et pratique" (1777); "Résultats généraux sur l'hybridation des vignes" (1894), etc.

The French wine-growers wished to show their gratitude to the memory of the Bordelais botanist for the multiple services he rendered to the French and foreign wine. The work of the sculptor Gaston Leroux, professor at l'Ecole des Beaux-Arts de Bordeaux, interprets by a pleasing allegory this sentiment of gratitude, and recalls the austere features, but stamped with wisdom and benevolence, that characterized the physiognomy of the great departed.

Millardet takes rank with the savants who shed lustre on the rich and sunny south part of France and like them he has now a monument worthy of his name and of his work. The honor was worthy of the workman. Perhaps the Europeans have a better remembrance than we have. Canadian agriculture has also its departed benefactors whose names should be engraved in bronze or marble.

ENTOMOLOGICAL TEACHING IN ITS RELATION TO FARM PROBLEMS

By Dr W. H. Brittain, Provincial Entomologist, Truro, N. S.

The speaker feels that no apologies are necessary for bringing up the question of entomological training for the farm boy, for it is a question that affects all those who may be engaged not only in teaching and extension work, but in experimental work as well.

Those charged with the administration of our agricultural colleges during the past few years have been much concerned by the constantly falling attendance. Where we used to have classes of fifty to sixty, we now have six and seven. The agricultural colleges, as a consequence, have come in for rather severe cristicism and many have gone so far as to accuse them of failure. The fact that a plant designed and staffed to accommodate several hundred students, handles instead a few score, gives much color to such criticism.

Of course it is easy to blame the condition on the prevailing depression in the agricultural industry and this is, without doubt, a potent factor. Another and important reason is the lack of openings for agricultural college graduates as compared with conditions several years ago. When opportunities foremployment in connection with the colleges themselves and in the constantly growing departments of agriculture, etc. were plentiful, there was a real incentive for students to attend the colleges, for while a certain number of students look upon the college as a place to receive an education and to train themselves for more effective work upon the farm, a great number have, in the past, looked upon the course as a stepping stone to a position in technical agriculture. Still

another reason to which many assign a large portion of the blame for the low attendance at our colleges,is the higher academic standard now required for entrance to the degree course. There is no time to discuss this subject at length here, especially as the speaker has already written at some length on this subject in an article which will shortly appear, but it is clear that this is but a minor factor, when we consider that even courses designed especially for farm boys and not leading to a degree for which no entrance acquirements are demanded have suffered in equal proportion.

Whatever the reason for this condition may be it has opened our eyes to this important fact, viz., that heretofore our attention has been focussed on those students who are preparing themselves for a degree to the detriment of the great majority who have no opportunity to take such work and who are in need of our practical assistance. The question is now being asked in many quarters. "Why should our province support an expensive institution to train men to leave our farms and, in most cases, our province and often even the Dominion?" The thought is expressed that, while something may be said for reciprocity in brains, we are now suffering from free trade in one direction only. However we may regard this question we must admit that for every students who takes advantage of our courses there are many who do not and cannot do so and most of us will also admit that even the instruction we have been giving in the past, however excellent it may be for the student proceding to a degree, is capable of considerable improvement from the standpoint of the future farmer. It seems to the speaker that, for this class of students, it is in the highest degree important that we encourage him to study his own business in a way that he has never done before and that we actively assist him in solving the problems that he has to meet in his every day life. If we are at all interested in our work we must make some effort to meet the present crisis and, if we know our business, we must adapt our teaching practices to meet the changing conditions of the day.

I would not be so presumptous as to venture a solution at the perplexing problem of how and what to teach so that the student can and will use it, but I want to indicate without too many details how the Nova Scotia Agricultural College is attempting to deal with the situation. While it must not be supposed for one moment that the same methods will apply to other and different conditions, it is hoped that the discussion of the problems involved will be provocative of thought and that some constructive ideas may be expressed that will be of value to all concerned.

Before taking up the specific question of entomological teaching, it will be necessary for me to outline in a broad way the kind of course that we plan to offer for that class of students who intend to make a life work of farming. For several years we have been offering a two year course of the same length as the regular or degree course and with some success, but we have now had enough experience with it to know that it does not entirely meet the needs of the case.

In the first place it has not satisfied the demand for a less expensive course In addition to this it has been found that, since the science instruction is necessarily of a simpler character than that required by the degree students, the instructors in the purely agricultural subjects have found that they have more time than is absolutely essential for the adequate presentation of their subjects. Without going into the merits and demerits of the alternative plans suggested, I may say that the one finally accepted calls for a course consisting of two three months periods given in two successive years, the term extending from Jan. 1st to April 1st. The course is to be an intensive one and of the most practical character. An earnest effort will be made to adapt the instruction to the student. He will be encouraged to bring forward his own special problems for solution. In his farm bookkeeping, farm management and kindred subjects, the instructors will endeavor to direct his assigned problems so that the student is, as far as possible, studying his own business instead of a purely imaginary one. An essential part of the scheme will be the working out by the student of certain simple problems between his first and second term. The nature of these problems will be determined entirely by the needs and ability of the student and rare good judgment will doubtless be required in assigning these problems. So much for the general statement of the course.

The foregoing explanation enables us to discuss intelligently the character and quantity of entomological work which will be taken up in connection with it. In stating my ideas as to what these should be, it should be understood that I am speaking only for the type of student and for the set of conditions with which I am familiar. The following then are what might be considered the essential features of such a course:

1. **There should be an abundance of good material.**—It is as impossible to teach literature without books as to teach entomology without specimens, and yet an insufficiency of material is a very common fault with elementary courses. The speaker knows of one institution where one battered codling moth served five different classes of students. At the end of that period the thorax and one wing was all that was left, but the specimen was still doing duty. At another institution, where scores of students took the elementary courses every year, there was one very indifferently mounted slide of a horse fly head supposed to show the mouthparts of this insect.

Many instructors who are very particular about the kind of material they give the advanced students, put aside poor or damaged material for their elementary classes. This is exactly the reverse of the proper practice. If it is necessary to use poor material the advanced student is more likely to be able to make something out of it than the beginner, who all too often has serious obstacles to his mastery of the subject placed in his path from this cause. For him the instructor should consider nothing too good.

This naturally entails an immense amount of work on the part of the teacher, but it is work that he must be prepared to do. All of us are acquainted

with the amount of material that can be ruined by a class of students, especially when it consists of pinned specimens. The wastage is often appalling and necessitates the constant renewal of the material. The speaker has found it advisable in all preliminary work such as elementary morphology and taxonomy to use specimens preserved in liquid. This enables the student to handle and study the specimens without the certainty of having them rendered unfit for further use.

2. **The course should be intensive rather than extensive and should not be designed to cover too much ground.**—Any instructor who is enthusiastic over his subject is naturally desirous of giving his student as much as he can in the time at his disposal. This frequently results in the general principles of the subject being smothered in a mass of detail. This is just as true for degree students as for those taking the kind of course that I am describing. Most of you have had the experience of having a colleague try to explain some insect that he has seen attacking some plant. Usually he cannot tell whether it was a bug or a beetle. In spite of the fact that he had had advanced courses in economic entomology and though insects and their activities are forced on his attention every day, he has completely forgotten all he ever learned about the subject. While it is quite natural to forget things we do not use, such cases do not come entirely in this category and the fault, I am convinced, can be attributed in a very large measure to the fact that when they took the work they were given more detail than they could assimilate in the time available.

All will agree that the student should be able to recognize an insect when he sees one and should know enough about mouth parts to distinguish the main types, that he should be familiar with the main orders and the main groups of economic forms within the order, that they should also be reasonably familiar with the immature stages of these orders, that he should be instructed in the preparation and use of such poison sprays or dusts as he is likely to use on his own farm and to be familiar with the injurious stages of the chief farm pests. In such a brief and practical course it would not be necessary for all the students to study exactly the same insects in their laboratory work. For example, a student may come from a fruit district and be interested in fruit alone. Naturally, in his case, emphasis should be placed upon the study of fruit insects, whereas if his chief interest were in live stock the insect pests of farm animals would naturally be given first attention. In our work this idea is being developed, but the extent to which it can be carried out will depend entirely upon the number of students and the assistance available in any particular department.

In dividing the work of the two terms, our practice is to give the general principles of insect structure, classification and control with a few striking examples, leaving the more detailed study of the application of these principles for the second term.

3. **The work should be presented in an interesting, a practical and a non-technical manner.**—Most teachers will agree with this general proposition, but

there will be some differences of opinion as to how this should be achieved. With this type of student it is very little use to give him anything in which he is not interested and which he is not persuaded will be of some advantage to him in his life work.

One of the difficulties that we have all felt is the necessity of having to use dead and preserved material. It is hard to get enthusiastic over a lot of pickled caterpillars or interested in pinned and mounted flies. It is of the greatest advantage to be able to use at least some living material. In the lesson on mouthparts a live aphis from the green house placed on its back in a drop of Canada balsam with legs and antennæ waving in the air and with its beak extending half-way down its abdomen gives a reaction that you can never get from a Cicada taken from a jar of formalin. Aphids, scale insects, etc. can be obtained from greenhouses, some species of leaf-hoppers can be hatched out during the winter months as can many species of moths that hibernate in the egg state. If a greenhouse is available these can be reared and studied there and their work, growth and transformations actually observed. Many animal parasites are, of course, available at this time and can be studied to advantage in the live state.

Then, since the students are eager for practical instruction a lesson in sprays and spraying should be introduced early in the course, preferably following that on mouthparts. The actual materials and the actual machinery can be studied at this time. While actual demonstration of their use is difficult, in fact impossible on a large scale, it is easy to devise a few simple experiments to show that the work is not all "theory" but that it is capable of actual use. If we can get the student to thoroughly appreciate the difference between biting and sucking insects so that they will remember it after they return home, we have done more than even more advanced courses sometimes do. A simple experiment with some greenhouse aphids and some leaf eating caterpillars performed in the greenhouse will demonstrate this in a way that the student will find hard to forget. Then such insects as meal worms, clothes moths, etc. may be studied in the living condition and made the object of simple fumigation experiments. The control of chicken lice or hog lice can also be easily demonstrated in the winter months. Work of this character tends to vitalize our subject and to save it from the "dry rot of academic biology."

Then to achieve our purpose the presentation of the subject should be non-technical. What valid reason can there be to compel the student to master a strange jargon which he cannot and will not use. When a student says he cannot learn any subject because he cannot remember all the long hard names, the instructor should endeavor to remove this difficulty from his path as far as it can be done. Why use up all the student's mental energy merely in memorizing technical terms so that he has none left to learn the subject itself? We might as well make up our minds that there is in the mind of the average student—I mean the average student who takes these courses—an ineradicable prejudice

against technical names. As soon as he hears one of these scientific terms he immediately tells himself that this is a hard, scientific subject and by scientific he means something difficult and unpractical. He therefore immediately shuts his mind against it—and the capacity of the student mind to resist the introduction of knowledge under these circumstances is practically unlimited. Personnally I do not share the average student's horror of long Latin or Greek names, but when I see that look of patient suffering come over the faces of successive classes of students, when they bear the word metamorphosis, I make up my mind to forego the use of this word entirely as far as our farm students are concerned and to invent a simple one that will convey the same idea. Similar terms such as mandibles, maxillæ, etc., are heard no more in our class room, but Anglo-Saxon words that serve our purpose equally well. Similarly there are no longer any Coleoptera, Hemiptera and Diptera, etc. but beetles, bugs and flies. It is our duty to give our students certain facts and a certain training, if we can do without clothing our ideas in technical language, surely it is better to do so and, if we are willing to take the trouble, it should be quite possible for us to devise suitable terms in cases where they are not ready to hand.

The use of keys such as are commonly found in our text books are also difficult for the boy taking this course to understand. Of course, with time, he can be taught to master them, but we have no time to spend unnecessarily and yet it is of the greatest practical advantage for them to be able to recognize the main orders of insects and not adults alone but their larvæ as well. For this purpose simple recognition charts may be devised which do not require the same amount of practice to use and which can be made to serve the purpose equally well.

All science teachers recognize the great value of drawings, especially in biological subjects. But here again it is easy to overdo the idea in the case of this class of students. There is not the time again and it is hard to convince these students that such time is well spent. While I would not do away with drawings altogether, I would reduce them to a minimum in this course.

Then the question arises in studying economic insects whether it is best to study them according to their natural grouping or according to their host. The speaker has experimented with both methods and feels bound to say that while the latter would seem to be the most natural one for this class of students in actual practice it does not appear to give the best results, in spite of its apparent greater simplicity. When we consider that almost every plant that grows is affected with one or more species of aphis, it will be seen that by studying insects according to the host plant the student has to make a separate mental effort for each species, whereas if he studies them simply as aphids, a single effort will enable him to master the main facts of aphid life history and control. Similarly the control of a leaf-eating caterpillar, whether it affects a turnip or an apple tree, is affected in a similar manner and this is perhaps the reason that

we have obtained better satisfaction in studying insects as cut worms, plant bugs, flea beetles, aphids, biting lice, etc., rather than as pests of various crops or animals. The information can later be summed up, however, in the form of spray calendars or schedules for different crops.

We must also recognize the fact that in the short time available we must not expect to give the student all of the subject. If his interest in and his study of the subject cease with his completion of our course then we have failed as far as that student is concerned. One of the obvious methods of keeping up the student's interest is to place him in touch with the sources from which bulletins relating to the subject may be obtained and to use these in our classes as far as practicable. One of the most important ways in which we can project our teaching on to the farm itself is by assigning simple problems to the students to be worked out between their first and second term of work. By careful questioning it can be ascertained what insect problems the student has to deal with on the home place and it is then the instructor's task to assign a problem that will be along the line of the student's needs and that will be within his ability to carry out. It is of great importance not to assign too hard a problem so that the student becomes discouraged. On the other hand, even a small success has an excellent effect in stimulating interest in the subject. We have already put this plan into practice to a limited extent with gratifying results so far.

In conclusion, whether or not you consider all my conclusions justified, I think it will be generally agreed that we should make an earnest effort to obtain the viewpoint of the student, for his viewpoint is likely to be a very normal one —at least as normal as our own. I realize that it is sometimes hard to do this. For example, it is hard to appreciate the viewpoint of the student who, in reply to the question, in a recent zoology examination, "Explain the importance of annelid structure in animal descent", replied, "The earthworm consists of two parts, (1) bilaterally and (2) symmetrical. It is a onecelled animal belonging to the order Protoplaza and feeds on vegetables, chiefly cabbage and is controlled by spraying with Bordeaux mixture in the pupal stage." One may get tired of hearing that aphids are controlled by hand picking the eggs during the winter months or that the strength of lime sulphur is tested with a barometer. At the same time we must realize our own responsibility in this matter and give as much time to the study of the student, mind as we do the specimens that we give him to study.

THE ORCHARD ENTOMOLOGIST

W. A. Ross, Entomological Laboratory, Vineland Sta., Ont.

As many of the members of this society are probably not familiar with the nature of a field entomologist's work, I do not think I could do anything better than present a paper, which I warn you will be rambling and disjointed, on the orchard entomologist.

His Training

First of all, what training should he have? Several excellent papers bearing on the training of an economic entomologist have been published recently in the Journal of Economic Entomology. In these papers the need of acquiring as broad an education as possible is forcibly pointed out; the importance of some grounding in fundamental sciences such as chemistry, physics, botany, zoology, ecology and meteorology as well as entomology is stressed; in brief all the chief requisites for a thorough training in economic entomology are dwelt on except one viz: some experience, the more the better, in farm or orchard work. I should not presume to add to what has been written by much more capable men regarding the entomologist's academic training, but I do feel contrained to say a word about the orchard practioner's need of having some orchard or farm experience.

The entomologist engaged in fruit insect investigations is concerned not only with insect pests, but also with the relations of the insects to the trees, of the trees to the insects, and of both of these to orchard practices. In combating the insect, in protecting the tree, he has to make use, not only of insecticides, but also of cultural measures. It is, therefore, fundamental that he should have some knowledge of horticulture and that type of knowledge which to a large extent can only be acquired from actual experience. Without this experience, he may lack a proper sense of proportion and may easily fall into the error of considering the control of some pest a problem in itself, and not, as it is in reality, merely a part of the whole problem of orcharding. Without this experience as a background, he may fail to realize that the fruit grower's business is primarily to grow fruit successfully and profitably, and not to kill bugs. Without this experience, he will work under as serious a handicap as that of a medical doctor who has not walked the hospitals—he will have scant knowledge of his patients the trees.

Some Minor Trials and Tribulations

An entomologist cannot afford to be too sensitive. He is very liable, particularly when he is fresh out of college, to meet hard-boiled fruit growers who take a grim delight in showing him how little he actually does know. He is apt to come into contact with men who take the good things he does for granted, but

who never forget his mistakes. He may find himself living among people who are convinced that anyone, who devotes his life to the study of insignificant creatures such as insects, must be queer. I know of one young entomologist, a close friend of mine, a youth with a hyper-sensitive soul, who was stationed in a small town in one of the apple growing districts of Ontario. About a week after he arrived in town, practically everyone knew him, not because he was particularly attractive or genial and sociable, but simply because he was a bug man. If he had been a bank clerk or anything other than an entomologist, he would have received little or no notice except possibly from flappers and their mothers, but because he was a bugman he very shortly had as much notoriety as one of Barnum-Bailey's freaks. In conversing with him everyone in town felt it necessary to introduce the subject of bugs. During hot weather he was usually greeted with—"Well Professor, this is great weather for hatching bugs." On wet days the greeting was changed to—"Well Professor this rain must have destroyed lots of bugs." Brought up in polite society in the Old Country where moths, butterflies, flies, etc., were designated insects, and where the term "bug", never mentioned above a whisper, was applied almost wholly to that disreputable creature *Cimex lecturlarius*, he being a sensitive youth, naturally detested the name bugman. It made his very soul writhe when he was introduced to some interesting damsel as Mr....., the bug man, and when he noticed her stare of astonishment which was invariably followed by a half suppressed giggle. Some of his friends were even ashamed of his profession and usually introduced him as "Mr..... who works and investigates in orchards you know." The only thing that made life possible for him was to get out among the fruit growers who appreciated the value of entomological work, and who looked on him as being more or less a normal, human being. Every story should have a happy ending, and this one has. In time this young man became hardened and finally reached the stage where he called all insects bugs and even referred to himself as a bugman.

His Workshop and Tools

The entomological laboratory should preferably be located in close proximity to fruit farms, so that the entomologist will be able almost literally to step out of the laboratory into the orchard. Situated in this way, living as it were in a horticultural atmosphere, he is not apt to become so wrapped up in the insect as to forget the orchard.

I shall not attempt to describe or even to list here laboratory equipment, as this sort of information can be readily secured from catalogues of supplies, and as the amount and kind used by the orchard entomologist vary considerably, depending on the nature of the investigations being undertaken, and still more on the funds available for buying supplies. Such equipment as a library or the nucleus of a library, compound and binocular microscopes, equipment for

Fig. 1.—Large Insectary, Dominion Entomological Laboratory, Vineland Station, Ont.

Fig. 2.—Interior of Insectary.

PLATE II

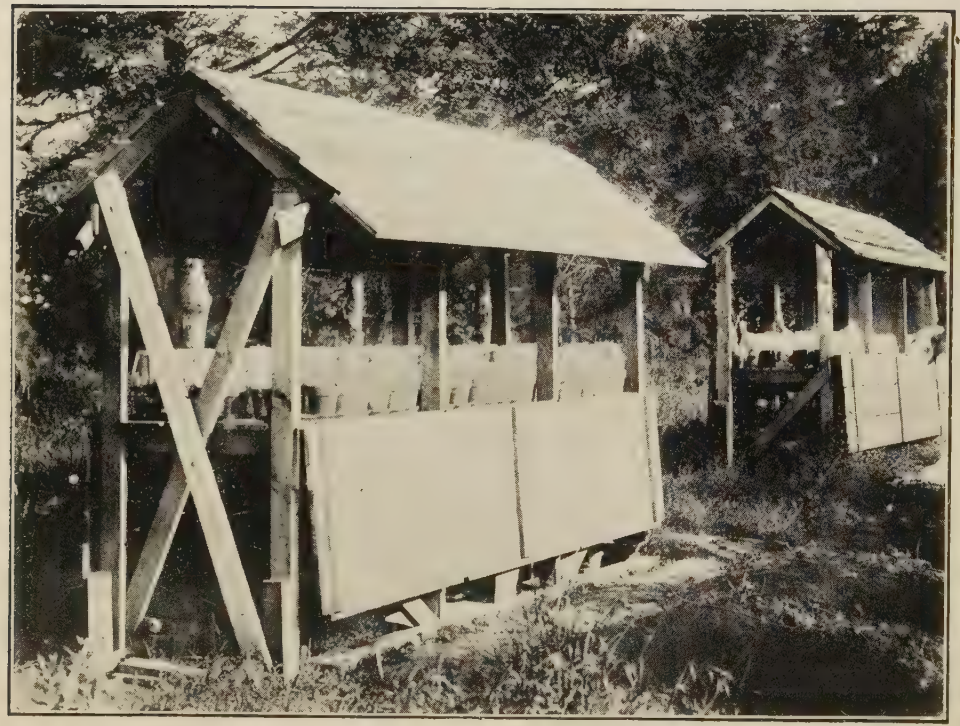

Fig. 3.—Covered Bench Insectaries

collecting and preserving insects, a camera suitable for indoor as well as outdoor work, a cabinet for filing notes, and some sort of spraying apparatus is very necessary. A motor car, preferably the ubiquitous Ford, is practically indispensable, particularly where extension work is being carried on. An insectary and breeding cages, the only equipment I wish to refer to in detail, are also most essential.

At Vineland we have one large and two small insectaries. The large insectary shown in figure 1 is *24'-4''* long, *10'-4''* wide and about *8'-3''* high, and is built on concrete piers. The four walls are covered with rustless wire screening. The interior of the building (figure 2) is fitted on each side with a bench 3 feet wide and 30 inches above the floor and with a shelf 18 inches wide and 30 inches above the bench, both running the full length of the inside; with a tight cupboard built on the back wall in which binocular microscopes, notes books, etc. are kept; and with a water pipe, tap and hose for watering the plants. The only furniture in the building are two home-made stools with small tables built on them on which the material being examined may be placed. Roll curtains made of water-proof, army duck, are fitted on the west and south sides to protect the material in the insectary during stormy weather. These can be readily let down and pulled up.

The two small insectaries shown in Figure 3 are of the covered bench type, with hinged sides which of course are down all the time except during a storm. We have used the covered bench almost exclusively for our work on aphids, and have found it very satisfactory. It has the one disadvantage, however, of not affording the observer protection from the rain on wet days.

Many kinds of cages are being used for rearing and studying insects, but the short time I have at my disposal will only permit me to refer to a few which we have found to be particularly satisfactory. The flower pot cage has, wherever it is practicable, no equal. In our investigations on aphids, pear psylla, potato and grape leaf hoppers and the European red mite, we used this cage almost exclusively. As shown in the illustrations (figures 4 and 5), it consists of a flower pot in which the food plant or plants are grown and of a glass or celluloid cover. For small plants an ordinary lantern globe with a cheesecloth top makes a satisfactory cover. Where the plants are larger, a celluloid cylinder, say 12 inches high and 6 to 7 inches in diameter may be substituted for the globe This cylinder is made from a sheet of clear celluloid. The edges are glued together with acetone, and the top and bottom are reinforced with aluminum tape fastened to the celluloid by means of eyelets; two narrow vents 7 inches by 1¼ inches are cut out opposite each other and are then protected with wire cloth sewn on with thread. The top is covered with cheesecloth and the cylinder is held down in position by means of a wire right-angled hoop with the ends forced into the soil. The celluloid cylinder also answers the purpose of a tree cage (figure 6) for studying the habits of an insect such as the codling moth, and I have no doubt it could be used for several other purposes.

The Riley cage, which needs no description, is eminently useful for rearing leaf-eating larvæ which have to be furnished with fresh food at frequent intervals. The leaves of the food plant can be kept reasonably fresh by placing the twigs or shoots in narrow necked jars containing water and the larvæ can be preserved from drowning by fitting the jars with cheesecloth or cotton batten stoppers.

Ground cages (figure 7) with wire cloth or cheese cloth sides and tops and with sliding doors are valuable for studying the emergence, etc., of insects such as fruit flies and sawflies which spend part of their life history in the soil.

Glass vials in Marx trays (figure 8) may be employed for rearing certain larvæ such as ladybird beetle grubs. At the present time we are using glass vials in our codling moth investigations. The vials with one larva in each are placed in pockets in burlap bands (figure 9) and the bands are tied around the trunk of the tree. The larva in this way are kept under conditions which closely approximate those of codling worms under the bark. It might be of interest to mention here that in replacing a band which has been removed for examination, care is taken to put it back in the same position, so that the insects, say on the south side of the tree, remain on that side of the tree until they emerge as adults.

Cheesecloth cages of different kinds are of value in field or plot work, where it is necessary to cover such plants as raspberries, currants and small grape vines. The cage shown in figure 10 has one end pinned to the sides with safety pins, thus making it possible to lift up the cheesecloth to any height desired in order to see what is going on inside.

Some of His Work

An investigation on a fruit insect pest generally comprises a careful study of its life history and habits under insectary and orchard conditions; a study of the injury to its host or food plants; a study of the effects which meteorological conditions, cultural practices and orchard environment have on its development and prevalence; a study of the parasitic and predaceous insects, birds, fungus and bacterial diseases which may attack it and of the effects which meteorological conditions, orchard environment, etc., have on them, and finally a study of methods of prevention and control.

In the insectary experiments the insects should be reared under conditions as nearly natural as possible. This calls for some ingenuity in devising and trying out various breeding paraphernalia. A simple, uniform system of labelling the cages, etc., should be adopted in order to simplify the recording of observations and in order to eliminate to as great a degree as possible the chance of mistakes being made. What I have in mind can be most easily explained by describing the system we use. In aphid experiments the stem mothers would be labelled as follows: 1_1, 2_1, 10_1, with the date of hatching immediately

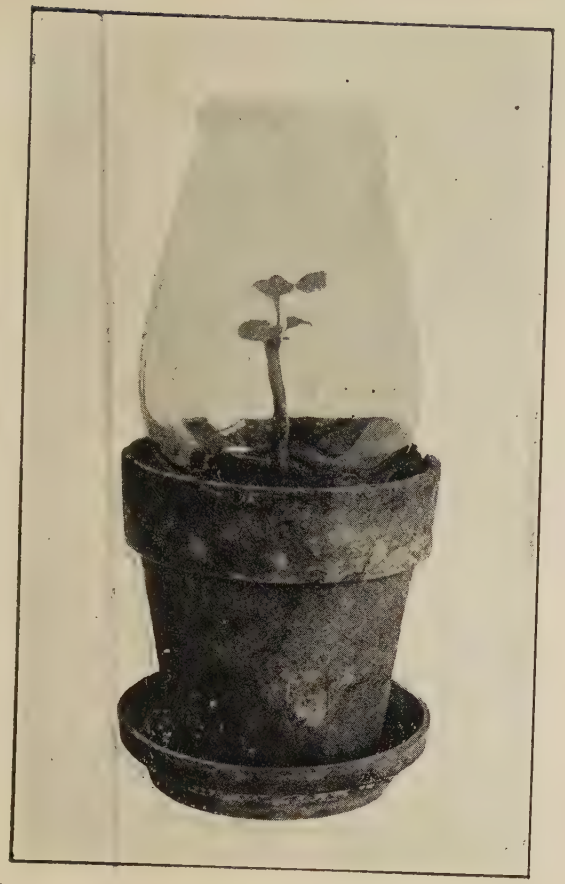

Fig. 4.—Lantern Chimney Cage

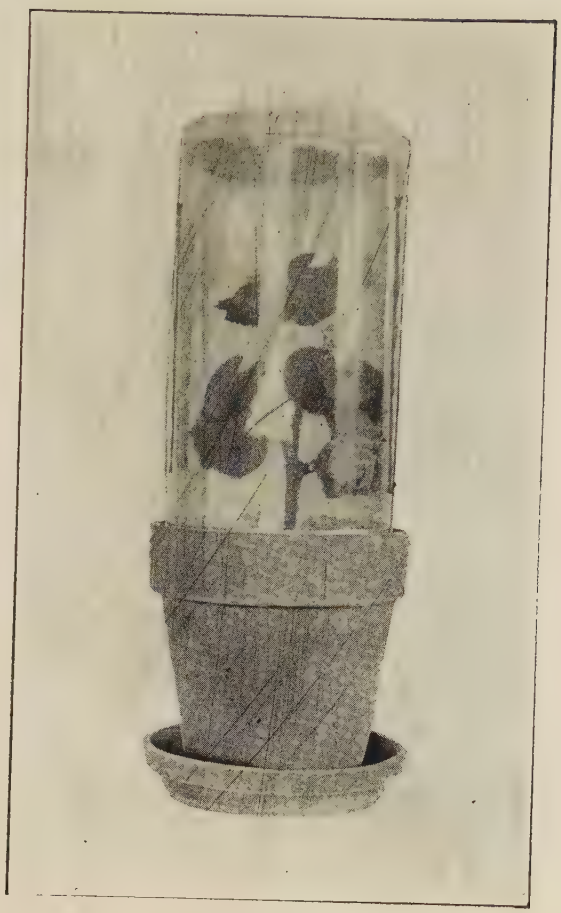

Fig. 5.—Celluloid Cap

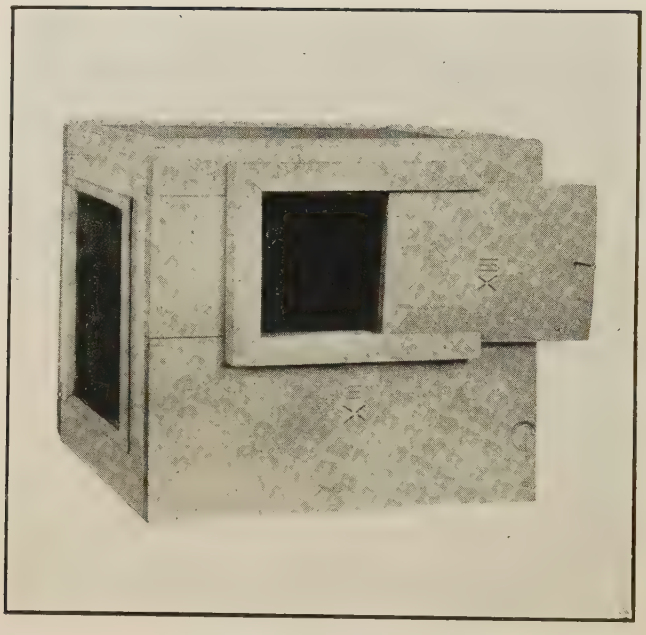

Fig. 7.—Ground Cage.

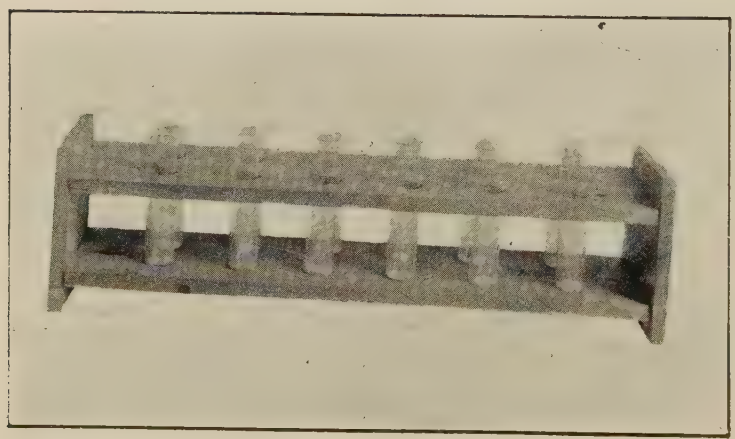

Fig. 8.—Marx Trays and Vials.

Fig. 6.—Celluloid Cages on Apple Trees.

PLATE VI

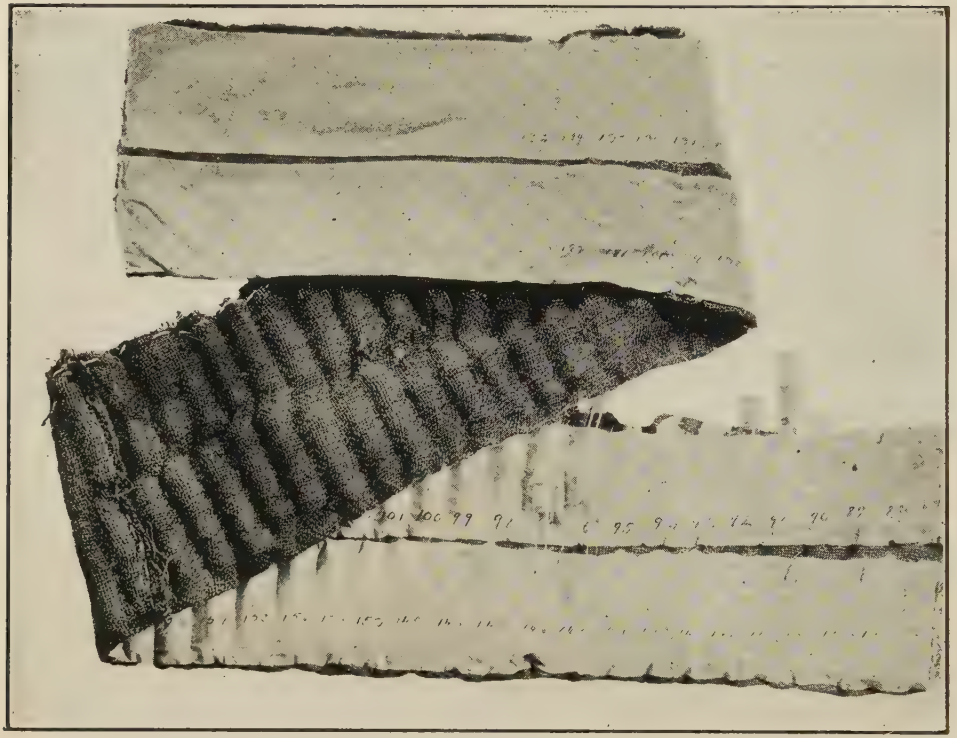

Fig. 9.—Tree band with vials for rearing codling moth larvae.

Fig. 10.—Cotton Covered Cages

beneath the experiment number. The large numeral is the experiment or line number, the small numeral is the generation number. Fourth generation aphids would be labelled: 1_4, 2_4, 10_4, in the first born series, and L 1_4, L 2_4, and L 10_4, in the last born series. 1_4 and L 1_4 would be great granddaughters of 1_1. With an insect like the pear psylla, the method of labelling would be modified in the following way: The overwintering adults would be, e.g. A1, A9, A15; the first generation eggs E 1_1, E 9_1, E 15_1; the first generation nymphus N 1_1, N 9_1, N 15_1; the first generation adults A 1_1, and so on. Notes recorded under these simple marks can in many cases be readily put into tabular form.

All important data secured from the insectary experiments should be checked up in the orchard. All critical stages in the insect's development should be, wherever it is possible, correlated with a stage of growth of some common plant, for example, the bursting of peach buds; the "pink" stage of apple blossom buds; the full bloom of European plums; the setting of Concord grapes, and the first blush of early cherries. Phenological records of this nature are highly desirable. They are more valuable than dates which vary too much in different seasons and in different localities. Weather records should be kept and notes should be made on everything having a direct or indirect bearing on the problem under investigation. Full notes should be taken immediately after the observations are made—the memory should never be trusted.

In carrying on control experiments, there are two important principles which should be kept in mind. The first one is that the control of an insect pest is not a problem by itself, but is merely a portion of the complex problem of orcharding. In working out a method or methods of control, the entomologist must take into consideration not only the effect of the treatment on the insect, but also its effect on other insects, on fungus diseases, on the trees, on the foliage and on the condition of the fruit. The second principle is that a remedy which is unduly costly is no remedy, because the orchardist will not adopt it. The question of cost is an extremely important one, and one unfortunately which some investigators are prone to lose sight of. Working in close co-operation with the horticulturist and plant pathologist, the entomologist's ideal should be to keep the cost of pest control down to the absolute minimum, by utilizing to the greatest extent possible horticultural practices such as orchard sanitation, cultivation and pruning; by keeping the number of spray applications down to a minimum, and by modifiing a spray schedule rather than by adding an application to it (wherever this can be done). Right here I feel impelled to plead for closer co-operation among orchard entomologists, plant pathologists and horticulturists. It is true that the entomologist, the plant pathologist and the horticulturist each has his special field of activities, but it is equally true that they have in common a most important field, that of pest control. More than that, they all have exactly the same ultimate object in view, viz: the production of profitable crops of high quality fruit.

In experimenting with insecticides, much time and labour may often be saved, useless materials may often be readily eliminated, very exact data may often be secured by conducting small scale experiments in the laboratory or insectary with definite numbers of eggs, adults or larvæ. The most promising materials can then be tested in blocks or plots, and finally under commercial conditions.

Because of the immensity of the field, and the comparatively small number of laborers in Canada, the orchard entomologist has to do a certain amount of extension as well as research work. Personally, I consider this a blessing and not an evil. I am of the opinion that the investigator who always has in his mind, as it were, a bird's eye view of the whole field of fruit growing is in the best position to secure results which can be converted into orchard practices. This bird's eye view can best be secured and retained by doing some extension work, by keeping in actual contact with fruit growers, and by seeing things from their point of view as well as from that of the entomologist. With this bird's eye view, the investigator is not apt to discover remedies which are impracticable because they are too costly, or because they are otherwise incompatible with commercial fruit growing.

Our extension work at Vineland embraces (1) answering inquiries received through the mail or over the telephone. (2) Visiting to as great an extent as possible, growers with special problems who call on us for assistance. (3) Adressing meetings of fruit growers. (4) Contributing articles to agricultural papers. (5) Sending out mimeographed letters with timely advice in them to men who are sufficiently interested to have their names put on our mailing list. (6) Conducting orchard demonstrations. We make it a rule to work only with bona fide fruit growers, or at least with men who make an honest attempt to grow good fruit, and our days are so fully occupied in doing so that there is little or no time left to devote to the indifferent farmer, who is not and never will be, a fruit grower. We have become sufficiently disillusionized to know that efforts put forth to reclaim neglected, pestridden orchards, which are in the hands of indifferent farmers, are doomed to failure, no matter how much enthusiasm, labour and time are expended.

PLANT DISEASES IN RELATION TO CERTIFICATION OF SEEDS

H. T. Gussow, F. L. S. Dom. Botanist

It is always of interest to review progress in science and the value of pure science applied to the many and varied problems engaging the attention of mankind. In agriculture and related industries we are especially interested; and all of us who have given thought to such a point must have realized how

difficult it is to express in dollars and cents the value of scientific research contributions to the national wealth of Canada. Indeed, it may be somewhat strange to be asked such a question, but nowadays, when everything has been more or less subject to inquiry by efficiency experts, such questions have cropped up again and again. I have always felt in this regard that scientific research cannot be assessed justly as to its value to a country's development, principally because development of natural and established industries is so largely a question of political economy. We may thus—as scientists—be able to solve a number of questions relating to increase of production from every point of view: but increase of production, with all its scientific foundation, does not solve the question of marketing what we have thus increased. In consequence you will agree that whatever we may calculate to be the dollar and cent value of scientific work relating to crop production, it is by no means the only aspect of progress and prosperity of agriculture.

Where, however, our duties commence is to aid in the production of a type or quality of commodity that will give the best and safest returns to the producer or consumer. Thus I wish to introduce the remarks which I wish to make to-day. In general they are applicable to every phase of agriculture, forestry and horticulture—animal as well as plant life.

A good many years ago agricultural seeds were sold in the markets of the world without any restriction whatsoever. It was not until the fundamental work of Stebler and Noble that attention was called to the fact that some of the seeds sold for seed purposes did not germinate. Samples of agricultural seed of very low percentage of germination were quite frequent in those early days, and attempts may even to-day be made to occasionally dispose of seeds of low germination. Gradually the sale of agricultural seeds and seeds generally, was made subject to germination tests, until in due time experience has shown that standard of germination which would make a seed a good and useful quality, and this standard eventually became compulsory by law.

These standards are now pretty nearly uniform in all progressive agricultural countries; but the results of such scientific observation or the application of such observation, rather, to practical problems, it would seem difficult to express in money values. Yet, the farmers of the world owe a great debt of gratitude to the painstaking scientific worker.

The next step in improving the quality of agricultural seeds was the determination of their purity. I do not need to refer here to the importance of this phase, knowing that you are all quite familiar with the merits of such aims. Agriculture has been immensely aided by the use of seeds of high germination and high purity, which includes foremost of all freedom from noxious weed seeds according to definite standards.

In Canada, we know that excellent work in this regard for the benefit of all users of seed, is being done in the Seed Commissioner's laboratories. I under-

stand that seeds of low germination and with impurities in excess of Canadian standards are not even permitted entry into the country.

Unfortunately, this type of work started nearly everywhere far too late. Witness the presence to-day in Canada of many noxious weeds of foreign origin, which cost the farmers thousands of dollars every year in attempts to eradicate.

Aside from the principal factors that a seed must be living and should be pure, progress in agricultural knowledge has revealed further desirable and essential features that constitute seed of superior value to the farmers. A seed must be true to type, true to name, of one variety, etc. To achieve this end it is necessary to start such inquiries before the seed has matured; the seed analyst cannot possibly do justice to these phenomena from a general examination of the seed. Naturally, I am quite aware that certain of these features may be recognized in the seed, especially of the larger kinds: it is simple enough in corn, peas and beans, more difficult in the case of cereals, but impossible in most of the smaller seeds, especially in those of vegetables of the cabbage type.

In consequence, the agrostologists, cerealists and plant breeders generally, joined forces with the seed analyst in studying and standardizing the requirements in this regard.

Their investigations gradually gave rise to what the Germans call "Saatenanerkennung", that is, the inspection of fields used for the production of seeds, and special recognition or certification of such, according to precise systems of inspections and according to kind of seed.

In this connection questions concerning origin of the seed, soil conditions, climate, position and yield, are receiving foremost attention, and necessarily so, since experience has again proved the best teacher in this regard. In reviewing the standards applied in many countries we note that the following constitute a workable basis:

1. Trueness to name, uniformity, purity of variety, freedom from other varieties, absence of weeds, protection from cross pollination and freedom from diseases.

2. Assurance as regards proper crop rotation and general satisfactory handling of seeds, including cleaning and marketing facilities.

As you know, this type of work is carried on in Canada by the Canadian Seed Growers' Association, according to the general principles referred to above.

There cannot be any doubt that present achievements in the production of a high type of agricultural seeds are the interesting results of evolution of knowledge, based upon practical experience and aided by scientific research.

Addressing an audience interested especially in the protection of plants from insects and disease, you will agree that we must start this protection with the seed that is planted; and while the factors referred to already constitute, each and all, most desirable features, a few words on the question of freedom

from disease of agricultural, of for that matter any kind of seed, may not be out of order.

Seed is produced for two reasons, first for direct consumption as such (peas, beans, corn, grain, etc.), and secondly for seed purposes.

In the case of the first group any standards applying to the quality of seeds for direct use by man will cover all those requirements which are more or less obvious.

The production of seed for seed purposes, however, should be subjected to the most stringent rules possible and practicable under the most advanced methods of cultivation. Ordinary methods will not suffice, even though they may be more practicable, but a grower who really desires to fulfill all the requirements of a superior seed must be prepared to go to considerable trouble and look towards the gain in price that is bound to be his, if successful.

Now, in regard to the point—freedom from disease. We require essentially freedom from all such diseases as are conveyed by the seeds themselves. Our inquiries should therefore be directed as follows. (a) diseases carried by seeds, and (b) diseases not carried by seeds; and the former be grouped into (c) diseases that may be controlled by seed treatment, and (d) diseases that are not controlled or difficult to control by seed treatment.

Hence, depending upon the nature of diseases present, entries should be made on the report forms.

Thus, if a grain field shows smuts of a type easily controlled by seed treatment, it should receive, notwithstanding, a more lenient treatment than cereals affected by smuts difficult to control, viz. the loose smuts of barley and wheat.

The great question of practical value, however, is, "Does our present knowledge enable us, as plant pathologists—and insect specialists—to give the definite type of advice in this regard which can be of value to the seed inspector in assessing this phase of his work? "

The ideal, of course, is as always that seed grown for seed purposes should be free from disease. No person should be exposed to the serious risks resulting from seeds that bear the germ of disease, for one can never foresee the conditions that may cause a comparatively slight original infection to assume the importance of a serious epidemic, which may not only result in the loss of the crop, but may also be the source of permanent soil infections.

We have learned important lessons in this regard from our seed potato inspection service now carried on by our division for some ten years or more. What is true of disease-free seed potatoes is equally true in the case of seeds proper. Yet our experience has shown that to demand absolute freedom from disease would at present not be practicable. In consequence, we have adopted a standard in regard to disease that for the present is as good as can possibly be achieved. No doubt as time goes on and conditions still further improve, we shall still be able to increase the quality of seed potatoes. In certain diseases

we cannot permit even now more than a very low percentage, viz. 2%, of leaf roll and mosaic and 3% of wilt and black leg.

There is, however, one very important point that we should consider,—though a disease may be easy or difficult to control by seed treatment, there is an important group of diseases which can not be recognized in or on the seed itself, at any rate, hardly in a quantitative sense such as would be possible to a more satisfactory extent in the field. No manner of simple analysis of seed would reveal the loose smuts of barley or wheat, the club roots of turnips and a good many more.

Hence, as far as a good many diseases are concerned, we should start in the field.

The first point to decide is which of the diseases affecting plants are really carried by the seed? Is the Cercospora spot of mangolds carried by the seed? The Phoma disease? Is it possible to safely distinguish the discolouration of the germ end of grain due to frost from various bacterial troubles?

It seems to me that the question of disease dissemination by means of seeds is an extremely important matter, to which it would appear that sufficient attention has not been given. I feel that this is largely due to the fact that accurate knowledge is lacking on the method by which seeds become infected and carry the diseases. The purpose of my remarks is principally to call the attention of plant pathologists to this matter and to encourage research along this line. I have in my mind to suggest the preparation of monographic studies; possibly this might be accomplished by post graduate workers, among other problems.

Far too little is known of the pathogenic organisms carried by the seed, and still less of the role of other organisms so persistently found on almost all seeds. I need only refer to the importance of the presence of the nitrogen fixing organisms on the seed of leguminous plants, as well as to the remarkable achievement of securing such good results from what would appear to be a symbiotic relation between fungi and the seeds of orchids. Surely investigations into these phases would seem to be warranted, and remarkably useful information may result from such studies.

There is certainly every need for a study of the pathogens, and there is promise enough from an inquiry into the relationship of bacteria and fungi to the seeds and growth of higher plants.

There is another aspect of this matter to which reference should be made. In the beginning I referred to the information which I have on the question of refusing admission into Canada of seed of low germination and purity. What if the presence of seed borne diseases were made a reason for the rejection of agricultural seeds? I mean agricultural seed in a proper botanical sense. In "seed" potatoes you know that such restrictions are already in existence. Indeed the presence of certain diseases in potatoes debars them from entry into Canada altogether—even from countries where the disease is prevalent, even though the potatoes themselves may be disease free. The recent discoveries of "take

all in wheat", of "Earcockle" etc., are cases in point, and in anticipation of such possibilities we wish to be prepared, in order to be in a position to discuss with some knowledge the risks involved.

A stuty of the diseases conveyed by seeds, the mechanism by which seeds become carriers, reliable information on the questions of rational and effective control of seed borne diseases, together with precise information on their recognition in field or in the package, you will agree is urgently called for.

OAT SMUT CONTROL EXPERIMENTS IN 1923

Dr B. T. Dickson, Macdonald College, Que.

Smut control experiments, conducted in co-operation with the Crop Protection Institute, were again carried out at Macdonald College using Hull-less 709 M. C. oats and **Ustilago levis** (K. and S.) Mag. The plots were 5 x 20 links in size, were replicated four times, and were separated by filler plots of the same size.

Grain was treated on May 25th and seeded on May 26th. On the day of seeding the moisture content of the soil was 9.5% and it continued comparatively dry until June 9th when a wet spell set in giving a period of four days with a soil moisture content of 25%. From that time on the season was normal.

The grain was heavily inoculated giving 70% of smut in untreated plots so that a reduction to less than 2% of smut by head count was quite satisfactory.

Several interesting observations were made which, while wellknown, are still worth recording. Concerning stooling, for example, the inoculated by uncontrolled plants stooled much more than treated as is shown in the following table.

STOOLING.—ACTUAL COUNT OF NUMBER OF CULMS.

Treatment	Plot A.	Plot B.	Plot C.	Plot D.	Total
Formalin Sprinkle	923	872	1210	1123	4128
$CuSO_4$ dip	732	850	1053	1027	3662
No treatment	1521	1695	1709	1703	6628
$CuCO_3$ dust	1031	806	1215	780	3832
No treatment	2262	1623	1720	1812	7417
$CuSO_4$ lime dust	1330	1009	907	1158	4404

GERMINATION WAS SOMEWHAT REDUCED BY THE TREATMENTS EXCEPT IN THE CASE OF CuS04 LIME DUST IN THE FIELD.

Treatment.	Lab. Germination	Field Germination	Yield in b.p.a.
Formalin Sprinkle	77	65	33.54 ± 2.38
$CuSO_4$ Dip	83	66	31.60 ± 1.74
No treatment	93	78	12.48 ± 0.64
$CuCO_3$ dust	93	75	36.62 ± 3.53
No treatment	93	80	12.15 ± 0.64
$CuSO_4$ – lime dust	80	83	38.57 ± 3.28

Times of heading and ripening varied with the treatments. The $CuCO_3$ and $CuSO_4$ lime dust plots headed on July 23rd while all the others headed on July 25th. The untreated plots ripened on August 23rd, the $CuCO_3$ and $CuSO_4$—lime dust plots on August 24th and the others on August 25th.

The percentage of smut by head count varied in the middle rows of the plots from the average except in the case of $CuCO_3$ dust, as shown in the next table.

SMUT COUNT BY HEADS.

Treatment	Av. % in all Rows.	Av. % in Middle Rows.
Formalin Sprinkle	1.8	0.9
$CuSO_4$ Dip	0.38	0.16
No treatment	72.8	74.0
$CuCO_3$ Dust	1.5	1.5
No treatment	70	74.0
$CuSO_4$ –lime dust	1.45	2.6

THE GENERAL RESULTS GIVEN IN THE FOLLOWING TABLE.

Treatment	Germination in lab.	Total Culm count	% Smut by total head count	Yield B.P.A.	Probable error.
Formalin Sprinkle.....	77	4128	1.8	33.54	± 2.38
$CuSO_4$ Dip.....	83	3662	0.38	31.60	± 1.74
No treatment.....	93	6628	72.8	12.48	± 0.64
$CuCO_3$ Dust.....	93	3832	1.5	36.62	± 3.53
No treatment.....	93	7417	70.0	12.15	± 0.64
$CuSO_4$ Lime Dust.....	80	4404	1.45	38.57	± 3.28

The writer wishes to acknowledge the following material help: land, seed and labour provided by Prof. Summerby, treatments by J. G. Coulson, M.A. and counts by J. G. Coulson, M.A. and T. C. Vaterpool, B.S.A.

The experiments are to be continued during 1924 with additional treatments by Uspulun, wet and dry, Semesan, wet and dry, DuPont dust No. 13, Deloro Nickel hydrates, Deloro Nickel carbonate, Nickel carbonate Harshaw, Fuller and Goodwin, and Sodium fluoride.

STUDIES CONCERNING INJURY TO SEED OATS AFTER SMUT DISINFECTION.

W. L. Gordon, B. S. A., M. Sc.

INTRODUCTION.

The following investigation was undertaken to determine the factors which induce injury to seed oats after smut disinfection, and if possible to find remedies for the injury. Different treatments, efficient in oat smut control, have been recommended in the past, but little has been definititely observed regarding the action of such treatments on the germination of the seed.

Scope of Investigations.

The present studies were carried on in the Department of Botany, at Macdonald College, McGill University, during the second term of 1922-23, and the second of 1923-24. They were thus of necessity, confined to the laboratory and green-house tests.

The following factors were considered :

1. Effect of varying strengths of formalin solution.
2. Effect of duration of treatment.
3. Effect of temperature of treatment solution.
4. Effect of carbon dioxide on the germination of treated seed.
5. Effect of presoaking before formalin treatment.
6. Relation of soil moisture to formaldehyde injury with limed and unlimed seed.
7. Effect of dry storage after treatment.
9. Comparison of the effects of different smut treatments.

It was planned to study the permeability of seed coats, and the effect of soil temperature on treated seed, but time did not allow the satisfactory undertaking of the work.

Historical Account of Seed Injury.

The injurious effects of fungicides upon the vitality of seeds have been studied by numerous investigators in various countries. Most of the investigations along this line have taken place in recent years. However, observations regarding injury have been made at irregular intervals for a half century. The results of some investigators are given below in chronological sequence.

Isidore, in 1876, found that seeds of wheat dipped in boiling milk of lime for two or three minutes lost the power to germinate; 54 per cent of the seeds germinated after being dipped for three minutes in a solution of 2 per cent copper sulphate, at 60 C., and 63 per cent at 50 C.

In 1891, Arthur observed that, when oats were treated with copper sulphate the plumules emerged earlier than the rootlets. This was due to "the fact that the primary roots were killed before starting and the secondary ones, which took their places, were consequently late in appearing".

Bolley, in 1895, stated that wheat dusted with air-slaked lime after having been sprinkled with a copper sulphate solution, was not reduced in germination to the same extent as seed treated with a copper sulphate solution alone.

In 1899, David ascertained that the degree of injury by formaldehyde varied with the different cereals, and was in direct proportion to the strength of solution and the duration of treatment. The seed injury was manifest in a retarded and abnormal germination in which no roots were produced. The injurious effects of the formaldehyde were reduced by soaking for fifteen minutes in a weak solution of ammonia.

Cranefield, in 1901, and again in 1902, observed that a formalin solution as weak as 2½ parts to 1000 injured the germination of oats. The injury varied from 6.4 per cent to 17.4 per cent. When stronger solutions were used the percentage of injury increased in direct proportion to the strength of the solution. An increase in the length of the time did not proportionately increase the injury when the standard formula was used (2½ parts to 1000).

In 1902, Mezentzov working in Russia, determined the effects of planting untreated and treated seed in a dry and moist soil. The treatments used were copper sulphate with and without subsequent lime-water bath, and hot water. He obtained higher germination percentages in moist soil, both with untreated and treated seed.

Stevens, in 1909, ascertained that the amount of injury to oats treated with formaldehyde depended upon the duration of treatment, strength of solution and quality of seed. Oats dipped in milk of lime after treatment with formaldehyde showed an improvement in percentage of germination.

Stewart and Stevens in Utah, in 1910, found that the injury to wheat, oats, and barley when treated with formaldehyde increased as the concentration of the solution was increased. Oats were more resistant to the influence of formalin than were wheat and barley. They state that of seed is thoroughly dried it may be kept for at least six weeks after treatment.

Gussow, in 1913, stated that chemicals, while very effective in controlling smut, exerts an injurious influence on the grain. Formalin treatment was found to exert a very curious influence upon wheat kept in storage after treatment. Figures regarding this, furnished him by Dr. C.-E. Saunders, Dominion Cerealist, show that wheat originally germinating 75 per cent had lost its life completely when retested one year later. A sample of oats originally germinating 62 per cent and one of barley with 71 per cent, germinated a year after treatment 2 per cent and 3 per cent, respectively.

In 1918, Kiessling in Germany, noted that individual lots of seed varied widely in their reaction to the injurious effects of formaldehyde. An apparent stimulation to germination occurred in some cases. Oats were not found to be injured by storage after treatment.

Braun, in 1920, determined that presoaking cereals in water decreased the injurious effects of formaldehyde and copper sulphate.

Hurd, in 1920, found that if treated wheat is held several days or more before sowing, it is severely injured if allowed to dry without thorough aeration during the storage period. The seed injury on drying was apparently due to a deposit of paraformaldehyde on the seed.

Howitt and Stone, in 1922, reported their results from the use of the dry formaldehyde treatment for oats. In the four years experiments the average percentage of germination of treated and untreated seed was found to be exactly the same, namely 97.5 per cent.

In 1923, Fraser and Simmonds at the University of Saskatchewan, reported that no seed injury resulted from the use of copper carbonate.

Tisdale et al., in 1924, came to the conclusion that with either a water or lime-water dip, after formaldehyde treatment, a greater part of the injury was prevented. With barley, and oats, the organic mercury compounds were found to improve the germination and yields, as well as the control of the smut.

Methods of Experimentation.

In the studies carried on to determine the injury to seed oats after smut disinfection the following varieties of oats were used, having the stated percentages of hull.

Hulled oats.	**Percentage Hull.**
Banner, 4407 M.C.	30.18
O. A. C. 72.	27.04
Alaska (G).	22.00

Hull-less oats.

Liberty, Ottawa 480.

For the purpose of comparison with the oats, as to amount and type of injury produced, the Marquis variety was used in many of the experiments.

The disinfectants used in the different studies were formalin (40 per cent solution), copper carbonate and Uspulun. These were obtained from the Department of Botany, Macdonald College, Qué.

The germination tests were carried out, either in the Botanical laboratory at room temperature, (17-20 C.), or in the greenhouse. The seed was placed to germinate, on sand, in sand, or in soil.

Seed lots, of 45 grams, approximately 1-10 of a pound, were usually used for treatment as well as for controls. From each seed lot, two, 100 seed samples were used for the germination tests. The percentage of germination was counted at least three times, the last count being made on the tenth day after planting.

Effect of Varying Strengths of Formalin Solutions.

In order to determine the relation between the strength of solution and the amount of injury produced by formalin treatment, the following experiment was undertaken. Seven strengths of solution were used; one pint of formalin to 60 gallons of water (1:60), one pint of formalin to 50 gallons of water (1:50), one pint of formalin to 40 gallons of water (1:40), one pint of formalin to 30 gallons of water (1:30), one pint of formalin to 20 gallons of water (1:20), one

pint of formalin to 10 gallons of water (1:10), one pint of formalin to 2 gallons of water (1:2).

The samples of seed were dipped for ten minutes in the different formalin solutions mentioned. The temperature of the solution was 18 C. In every case, as a control, similar samples of seed were dipped in tap water for the same length of time.

After treatment the seeds were drained for ten minutes and covered for one hour. They were allowed to dry and then placed to germinate on the top of moist sand in flats. The flats were placed in the greenhouse, kept at a temperature of 19–22 C.

When germination commenced, the number of seeds which had germinated were counted each day and recorded. The final count was made on the tenth day after the seeds were placed to germinate.

In the following table, the percentages denote the average of the two samples of seed, of each variety.

TABLE I.

Effect of Varying Strengths of Formalin Solution.

Solution Strenght	VARIETIES				
	Banner, 4407 M.C.	O.A.C. 72	Alaska (G)	Liberty, Ottawa 480	Marquis wheat
1:60	98.5	99	98.5	83	91
1:50	98	100	98	77.5	90.5
1:40	100	99	99	62	90
1:30	98	100	98	61.5	83
1:20	98	99	100	55	65
1:10	95.5	97	96	38.5	40
1:2	45	53	43	0	0
Control	100	99	100	87.5	91

It will be noted from Table 1. that all the formalin solutions, except the solution strength of 1:2 had very little effect upon the germination of the hulled varieties of oats. Both the Liberty oats and the Marquis wheat were reduced in percentage of germination as the strength of the solution was increased. It will be observed, however, that the Liberty oats were much more sensitive to the action of the formalin than the wheat.

Repetition of these tests gave practically identical results. Therefore, it seems evident that, for the control of smut in the Liberty oats, the formalin treatment is not a satisfactory one, owing to the injury incurred by the seed. It appears, however, that the hulled varieties can be subjected to the formalin treatment, necessary for smut disinfection, without injury occurring to the germination of the seed.

Effect of Duration of Treatment.

To test the effect of duration of treatment, two, 100 seed samples of the different varieties of seeds were counted out and dipped in a solution of formalin, 1 pint to 40 gallons (1:40), for varying lengths of time. The control samples of seed were dipped in tap water, instead of the formalin solution, for the different lengths of time.

After treatment the seed was drained for ten minutes, covered for one hour, and then allowed to dry before being placed to germinate. The seed was germinated on the top of moist sand, in flats kept in the greenhouse, at a temperature of 19–22.5 C.

In the following table the percentages denote the average of two samples of seed of each variety.

TABLE II.

Effect of Duration of Treatment.

Duration of Treatment	VARIETIES				
	Banner 4407 M.C.	O.A.C. 72	Alaska (G)	Liberty Ottawa 480	Marquis wheat
10 minutes :					
Treated	99	99	100	83	97
Control	99	98.5	99	92.5	96.5
30 minutes :					
Treated	100	99	98	78.5	96
Control	98	99	98	91	97
1 hour :					
Treated	98.5	98	94	68.5	94.5
Control	100	99	95	95	95
2 hours :					
Treated	100	100	98.5	65.5	91
Control	100	97.5	99	97	95.5
4 hours :					
Treated	97.5	98	95	60.5	89
Control	99	100	100	97	94
16 hours :					
Treated	85	92.5	82	6	
Control	96.5	97.5	97.5	87	
32 hours :					
Treated	84	91.5	77.5	4.5	
Control	98.5	98.5	97	92.5	

It will be readily observed from Table II that the ordinary duration of treatment is not a factor of primary importance in the germination of the hulled varieties, when the seed is dipped in a solution of formalin of 1 pint to 40 gallons (1:40). There was, however, a decided injury when the seed was treated for

an unusually long period. This injury showed itself both in a retardation and reduction in germination.

The Alaska variety was injured to a greater extent than the other two hulled varieties. The greater injury, in this variety, appeared to be due to the fact that, when the seed was soaked for any length of time in a solution, the hull became loose around the kernel allowing the formalin solution to penetrate to the embryo more easily.

It was noted that where germination was adversely affected, it was nearly always due to the failure of the radicle to emerge, although in some cases the plumule was also distorted. There were also cases where neither the plumule nor the radicle appeared.

The Liberty oats were injured in proportion to the duration of treatment. Extending the duration resulted in extreme injury being produced. The type of injury in this variety was the same as that already mentioned.

It can be concluded from the results, obtained in the above experiment, that hulled oats may be subjected to the formalin treatment, for a considerably longer duration of time than that required for smut disinfection, without any appreciable injury to the seed. The Liberty oats are very sensitive to the action of the formalin solution, and any unnecessary amount of time taken in treatment may result in extreme injury to the seed.

Hurd (1921) of the United States Department of Agriculture, found that the temperature of the solution was a factor in the resistance of wheat to long immersions in a saturated copper sulphate solution, the germination being poorer as the temperature increased. It was thought that probably a similar relation might exist with oats, even when the recommended strength of formalin solution for smut control was used.

Samples of seed, taken as in previous experiments, were dipped for ten minutes in a formalin solution of 1 pint to 40 gallons (1:40), at the different stated temperatures. Control samples of seed were dipped, for the same length of time in tap water at the same temperatures. The solutions were maintained at the required temperatures by means of bunsen burners. The beakers containing the solutions were placed in hot water baths at the respective constant temperatures. After treatment the seeds were drained, covered for an hour, allowed to dry and placed to germinate as previously.

In the following table the percentages given are the average of two samples of seed of each variety. The germination count was made at the end of ten days.

TABLE III.

Effect of Temperature of Treatment Solution.

Varieties	TEMPERATURES				
	10 C.	18 C.	30 C.	35 C.	40 C.
Banner, 4407 M. C.:					
Treated	99	98.5	98	98	98.5
Control	99	98	99	97.5	98
O. A. C. 72.:					
Treated	98.5	99	97	96.5	98
Control	99	100	97	97	99
Alaska :					
Treated	97	99	96.5	98	94.5
Control	97	98	97	99	97
Liberty, Ottawa 480 :					
Treated	89	81.5	78	76	61
Control	98.5	93	98	94	94
Marquis wheat :					
Treated	96	96	89	84	82
Control	98	96.5	96	92.5	90

There was no appreciable reduction in germination of any of the hulled varieties, either with a low or high temperature of solution. With the Liberty oats there was a gradual decrease in the percentage of germination as the temperature of the formalin solution was increased.

Effect of Carbon Dioxide on Germination of Treated Seed.

The fact that seed germinated in an atmosphere of carbon dioxide, are retarded or reduced in their germination has long been known. The present experiment was carried out to determine whether formalin seed were more injured than untreated seed when germinated in an atmosphere of 50 per cent carbon dioxide and 50 per cent air.

Samples of Banner, a hulled variety, and Liberty, a hull-less variety were taken and treated for ten minutes in a solution of formalin of 1 pint to 40 gallons (1:40). The control samples were dipped in tap water for the same length of time.

The treated and the untreated samples of seed were placed to germinate on pieces of wet blotting paper, in the bottom of petri plates. The petri plates were floated in the sink partially filled with water. Over these was inverted a graduated bell-jar. The air inside the jar was adjusted to 3 litres by means of water displacement. Carbon dioxide was then generated and added to the bell-jar by means of a rubber tube placed under the bell-jar beneath the water.

The carbon dioxide was then allowed to enter into the jar until the water was driven down to the 6 litre mark. This atmosphere, of half carbon dioxide

and half air, was retained by adding sufficient carbon dioxide each day, to keep the water at the 6 litre mark. It was found that the water absorbed considerable of the gas, requiring an addition to be frequently made.

As a further control another set of seed was placed under a bell-jar, in a similar manner, in an atmosphere of air alone. Observations regarding the rate and type of germination were made each day on the different lots of seed.

In the following table the germination percentages of the different lots of seed are given.

TABLE IV.

Effect of Carbon Dioxide on the Germination of Treated Seed.

Atmosphere	VARIETIES	
	Banner, 4407 M.C.	Liberty, Ottawa 480
Carbon dioxide and air :		
Treated	93	63
Control	94	83
Air :		
Treated	96	81
Control	98	96

As was be expected, there was a retardation in all the seeds germinated in the atmosphere of carbon dioxide compared with those germinated in the atmosphere of air. No retardation was evident in the Banner oats treated with the formalin solution, and germinated in the atmosphere containing carbon dioxide, compared with the control in the same atmosphere. There was, however, a noticeable difference in the rate of germination in the Liberty oats. The retardation was followed by a reduction in germination. The above results would suggest that the Liberty oats were more sensitive to the inhibitive action of the carbon dioxide than the Banner.

Effect of Presoaking Before Formalin Treatment.

The previous experiments have shown that the Liberty oats are apt to be extremely injured by the formalin dip method of treatment. In order to find a means of preventing or reducing this injury, presoaking of the seed in water was resorted to before the seed was dipped in the formalin solution. Braun (1920) found that this was a helpful means of reducing and preventing injury to seed wheat due to chemical disinfectants.

Lots of seed, obtained in the usual manner, were soaked in tap water for three hours, drained, and kept in moist chambers for three hours. On removal of the seed from the moist chambers, part of each variety was taken and treated

in formalin solutions of the following strengths, 1 pint to 40 gallons of water, 1 pint to 20 gallons and 1 pint to 2 gallons. The different lots of seed were dipped for ten minutes in each solution, the temperature of the solution being 18 C. After treatment the seed was drained, covered for an hour, and spread out to dry. As a control for the above, similar sets of seed were simply treated in the formalin solutions, without being presoaked.

When dry, two, 100 seed samples were taken from each seed lot treated and planted in soil in flats. The moisture content of the soil at the time of planting was 16.2 per cent. This moisture content was maintained as nearly as possible during the period of germination.

In the following table the percentages of germination, at the end of ten days from the time of planting are given. The figures denote the average of the two samples of seed.

TABLE V.

Effect of Presoaking Before Formalin Treatment.

Solution Strength	VARIETIES				
	Banner, 4407 M.C.	O.A.C. 72	Alaska (G)	Liberty, Ottawa 480	Marquis wheat
1.40 :					
Presoaked and treated.....	91.5	98.5	92	52	91
Treated only.....	90	98.5	91.5	20.5	90
1.20 :					
Presoaked and treated....	64	68.5	64.5	5	50
Treated only.....	64	65.5	65	.....	38
1.2 :					
Presoaked and treated....	.....	.....	.....	.....	1.5
Treated only.....	.....	.....	.....	.....	.....

The figures in Table V show that the presoaking of the seed as outlined was of no special value, if any, to the hulled varieties of oats, in reducing seed injury. The presoaking was advantageous in reducing the injury to the Liberty oats but unless the seed is planted at once or dried quickly after treatment it is liable to commence germinating.

The chief value of the presoaking before treatment, was the apparent stimulative effect it had on the germination of the seed. The seedlings of presoaked seeds, of all varieties, treated in a formalin solution of 1 pint in 40 gallons, had emerged on the fourth day after planting. None of the other seedlings were noticeable at the time. They were a day later in appearing above the surface of the soil.

Fig. 1.—The characteristic type of injury to the hulled varieties produced by formalin treatment. Note the absence of radicles.

Fig. 2.—The characteristic type of injury to the Liberty oats produced by formalin treatment.

PLATE II.

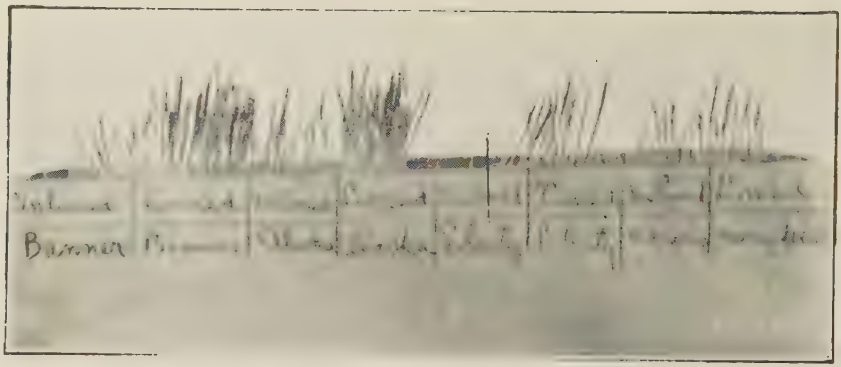

Fig. I.

Note root systems.

Formalin only.

Milk of lime dip after formalin.

Fig. II.

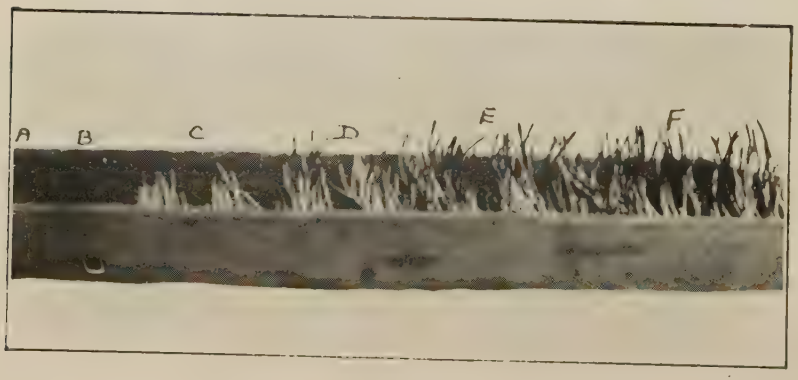

Fig. III.

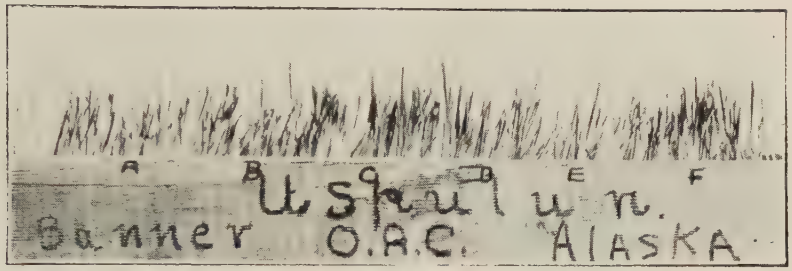

Fig. 1.—Showing the effect of Uspulun on the germination and growth of the hulled varieties of oats. Apparently, there is no stimulative or retarding effecting due to the treatment.—A. Banner, treated.—B. Banner control.—C. O.A.C. treated.—D. O.A.C. control.—E. Alaska, treated.—F. Alaska control.

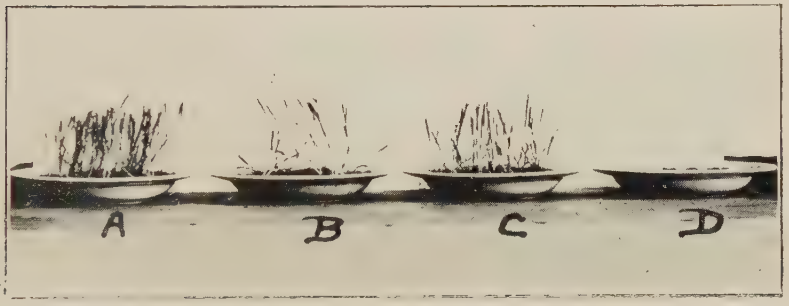

Fig 2.—Comparison of the effects of different smut treatments. The different sets of seeds were planted in soil, as shown. A. Liberty oats treated with Uspulun. —B. Liberty oats, treated with copper carbonate.—C. Liberty oats, control, untreated.—D. Liberty oats treated by the formalin dip method.

Fig. 3.—Showing the root systems of the sets of seeds in Fig. 2.—A. Liberty oats treated with Uspulun.—B. Liberty oats treated with copper carbonate.—C. Liberty oats, control, untreated.

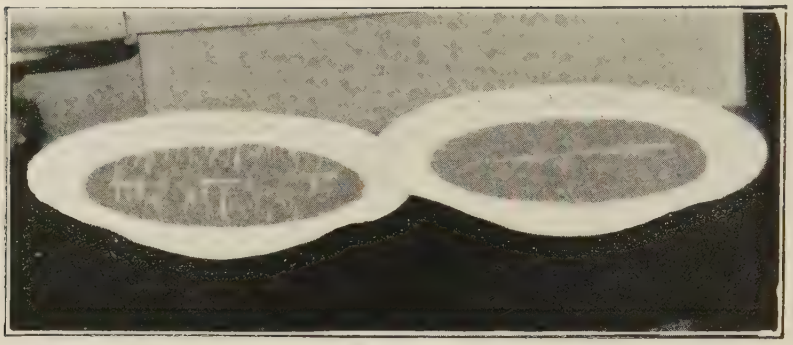

Fig. 1.—Showing the effect of Uspulun on the germination and growth of Liberty oats. The seed was planted in moist sand.—A. Liberty oats treated with Uspulun.—B. Liberty oats, control.—Photographied five days after planting.

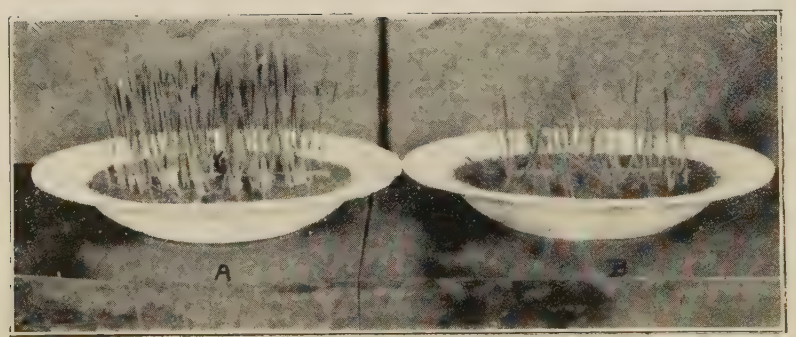

Fig. 2.--A Same as above.—B. Same as above. –Photographied ten days after planting.

RELATION OF SOIL MOISTURE TO FORMALDEHYDE INJURY WITH LIMED AND UNLIMED SEED.

The following experiment was carried out for two purposes. Firstly, to determine the relation of soil moisture to formaldehyde injury, and secondly, to determine the value of a milk of lime dip after the formalin treatment.

The different seed lots were dipped in the formalin solutions for ten minutes. When removed they were drained and covered for an hour. After they were uncovered, part of each seed lot was dipped in a 1 per cent milk of lime solution for ten minutes.

After treatment, samples of seed taken in the usual manner were planted in a dry and wet soil. The dry soil had a moisture content of 8.5 per cent, and the wet soil 19.6 per cent, at the time of planting. After the seed had been in the dry soil for three days, it was made up to the same moisture content as the wet soil. The results are presented in following table:—

TABLE VI

Relation of moisture to formaldehyde injury with limed and unlimed used.

Solution	Soil	Banner 4407, M.C.		Alaska (G).		Liberty 480 Ottawa		Marquis wheat	
Strength		Unlimed	Limed	Unlimed	Limed	Unlimed	Limed	Unlimed	Limed
1:40	Dry Soil.....	90.5	93.5	86.5	93.5	24	39	85.5	92.5
	Wet Soil.....	90.5	92	86.5	94	25	37.5	87.5	93.5
1:30	Dry Soil.....	95	98.5	94	96	28	71	77	90.5
	Wet Soil.....	95	98	94.5	97.5	21.5	67.5	80.5	92.5
1:20	Dry Soil.....	88.5	98.5	80	97.5	8.5	49.5	51.5	90.5
	Wet Soil.....	89	98.5	80	97	10.5	41	61.5	82.5
1:10	Dry Soil.....	74	84.5	63	79.5	6.5	44.5	41	60
	Wet Soil.....	74.5	85.5	64	79.5	12	45	58	85
1:2	Dry Soil.....	7.5	40.5		47		6.5		19
	Wet Soil.....	8	41	2.5	47.5		8	1	23
Control	Dry Soil.....	92	91.5	89.5	89	69	68	89.5	90.5
	Wet Soil.....	92	91.5	90	90.5	71.5	71.5	90.5	87.5

Note—Control, unlimed.—seed was dipped in tap water for ten minutes.
Control, limed.—seed was dipped in tap water for twenty minutes.

The most outstanding result of this experiment was the beneficial effect on germination produced by the milk of lime dip after the formalin treatment. In all cases it resulted in an increase to germination over the unlimed seeds, with both the wet and dry soils.

Besides reducing the percentage of injury to germination, the milk of lime dip appeared to hasten germination in many cases. In all cases the limed sets of seed emerged from the soil ahead of the unlimed, and in some cases ahead of the controls.

The beneficial effect of the milk of lime dip was more pronounced as the strength of the formalin solution increased. There appeared to be a greater development of the root system of the limed seed, than of the unlimed seed.

Although there was little difference between the percentages of germination, of the oats planted in the dry and wet soil, it is possible that there would be a greater reduction in the germination of the seed planted in the dry soil if the moisture content had been maintained at 8.5 per cent for a longer time. This is evidenced by results in the field when seeding time is very dry as in May 1923.

EFFECT OF DRY STORAGE AFTER TREATMENT.

It is often found convenient, and sometimes necessary, to store oats for a period before planting. This may be carried out in order to save time in the busy season, or it may be necessary because of weather conditions not being favorable for planting immediately after the seed has been treated. This practice has been considered doubtful, on account of reports of cases of seed injury occurring when seed was stored.

Samples of seed were taken in the usual manner, and dipped in a solution of formalin, 1 pint to 40 gallons, for 10 minutes. After being drained, and covered for an hour, they were spread out to dry at room temperature. When dry, two, 100 seed samples of each variety were placed to germinate on the top of moist sand, in flats, in the laboratory. Each succeeding week, samples were taken and germinated in the usual manner. The seed was stored in open flasks in the laboratory, at room temperature.

As a result of this experiment, it was noted that the hulled varieties of oats were not injured by storage for a period of nine weeks. The Liberty oats and the Marquis wheat, however, were injured to a marked degree when stored only for one week. This injury increased until after four weeks storage, when the percentage of germination was slightly better.

The writer is of the opinion that the hulled varieties can be stored, after treatment with formalin, provided they are dry. This was observed to be the case in later experiments, when the seed was treated with different must treatments, and stored for a period of ten months. The Liberty oats appear to be too sensitive to formalin to allow being stored after treatment.

Comparison of the Effects of Different Smut Treatments.

The purpose of the following experiment was to determine and compare the effects of different smut treatments for oats on germination, with special reference to seed injury.

Methods of Treatment.

Dip Method. The seed lots were dipped in a formalin solution of 1 pint of formalin to 40 gallons of water for ten minutes, drained, covered for an hour and spread out to dry at room temperature.

Sprinkle Method. The seed lots were sprinkled with the formalin solution, of the above strength, at the rate of 1 gallon of the solution per bushel of seed. The seed was covered for four hours, then spread out to dry in a thin layer.

Spray Method. Each seed lot was sprayed with a formalin solution, at the rate of 1 pint of formalin to 1 pint of water to 50 bushels of seed. After treatment the seed was covered for five hours, and then spread out to air to allow the escape of any remaining formaldehyde gas.

Copper carbonate Method. The seed was shaken in a bottle with copper carbonate at the rate of 2 ounces per bushel of seed, until each seed had a covering of the dust.

Uspulun Method. The seed was soaked for two hours in a .25 per cent solution, drained, and allowed to dry.

One set of seed of each treatment, was placed to germinate on moist sand in flats, or planted in soil in flats, kept at room temperature. Dry storage of treated seed took place in the laboratory.

The rate and method of germination was observed until the tenth day after planting, when the final count was made.

It was observed, from the germination tests carried out in this experiment, that the different formalin treatments had little or no injurious effect on the germination of the hulled varieties of oats, although stored dry for a period of ten months. It was noted with all the formalin treatments, that, in some cases, there appeared to be a retardation of the radicles of the treated seed, compared with those of the control sets of seed. The plumules of the treated seed emerged quite as readily, and appeared to be as high in vitality as those of the control.

The hulled varieties were not reduced in percentage of germination by the copper carbonate treatment. A slight retardation, rather than any stimulative action, was observed to occur in the treated seed germinated at the end of ten months.

The Uspulun treatment was not observed to injure the hulled varieties of seed, although treated seed was dry stored for a month. No stimulative action of the treatment on the seed was apparent.

The Liberty oats were injured by all of the formalin treatments, although germinated immediately after treatment. This injury was increased by dry storage for one week. Ten months dry storage, however, did not produce a corresponding amount of injury of the treated seed.

The copper carbonate treatment did not reduce the percentage of germination, but after ten months storage slightly increased it. No retardation of germination was observed to occur.

The Uspulun treated seed emerged ahead of the controls, produced a much stronger growth, and germinated with the highest percentage. There appeared to be a distinct stimulation due to this treatment, instead of marked injury as with formalin. Dry storage for a month did not have any injurious effects on the germination the treated seeds germinating with a higher percentage than the controls.

A comparison of the root systems of the seed, treated by the different methods, revealed a similar condition to the tops. The Uspulun treated seed had the greatest development of roots.

All of the formalin treatments, from the experiments carried on, appear to be equally safe with the hulled varieties of oats, and equally injurious to the Liberty oats. As a means of reducing, or preventing, seed injury to the Liberty oats, both the copper carbonate and the Uspulun treatments are worthy of note. The writer considers that the Uspulun treatment is the better one, because of the apparent stimulative effect on germination which it produces.

SUMMARY.

As result of work carried on with three varieties of hulled oats, and one hull-less, to determine the effects of formalin, copper carbonate, and Uspulun on germination, it was found that:

1. The hulled oats could be subjected to the formalin treatment necessary for smut disinfection without injury occuring to germination. Dry storage for several months did not induce seed injury.

2. The Liberty oats were seriously injured by the different methods of formalin treatment for smut. Dry storage after treatment increased injury.

3. With the Liberty oats, the temperature of the formalin solution was found to be a factor in the production of injury.

4. Presoaking the seed in water before the formalin treatment was found to reduce seed injury with Liberty oats.

5. The characteristic type of injury due to formalin treatment was observed to be a retardation in emergence or a killing of the radicle, rather than injury to the plumule.

6. Dipping the seed in a milk of lime solution after the formalin treatment was found to be distinctly advantageous in reducing seed injury.

7. Copper carbonate did not reduce the germination of the hulled oats.

8. The germination of the Liberty oats when treated with copper carbonate was usually as good as the control.

9. Oats treated with copper carbonate and dry stored for several months were not reduced in germination.

10. Uspulun was found to be non-injurious to the germination of the hulled oats. It appeared to be a stimulant to germination in the case of the Liberty oats.

11. Oats treated with Uspulun and dry stored for a month showed no reduction in germination.

This article is an abridgment of a thesis taken under Dr B. T. Dickson in the Department of Botany, Macdonald College, and submitted to the Graduate School of McGill University in partial fullfilment of the requirements for the degree of M. S. C.

The writer wishes to acknowledge with gratitude his indebtedness to Dr. Dickson for the many valuable suggestions and helpful advice given him during the course of the investigations. In addition he wishes to express his thanks to the Agronomy Department, Macdonald College, Que., and to the Cereal Division, Central Experimental Farm, Ottawa, Ont., for the seed oats and wheat used throughout the experiments.

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A PRELIMINARY NOTE ON SOME ENDOPHYTIC PROTOZOA.

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The first record of a protozoon parasitic in plants was made by Lafont in 1909, when he and his assistant David discovered in Mauritius a flagellate parasitic in the latex of *Euphorbia pilulifera*. Lafont named this organism *Leptomonas davidi*, and two years later announced that a hemipterous insect *Nyssius euphorbiae* is responsible for its transmission. Since that time several workers have contributed to our knowledge of *L. davidi*—its morphology, hosts and method of transmission. Other workers have shown that this is not an isolated case but that many other lactiferous plants, belonging to several unrelated groups, carry flagellates and amoebae in their latex. In this connection special mention should be made of a series of excellent papers published by G. Franchini of the Pasteur Institute of Paris.

In the summer of 1923 the writer commenced a survey of the lactiferous plants in his vicinity, and was gratified to find flagellates or amoebae constantly present in several species of indigenous and exotic plants. The following plants

have been studied more particularly: *Asclepias syriaca, Convolvulus sepium.*, Norus alba, *Lactuca canadensis, Apocynum sp., Lactuca sativa Hieracium aurantiacum, Taraxacum officinale Ficus sp. Sonchus spp., Euphorbia sp. Chelidonium majus.* Evidences of the presence of protozoa have been found in certain other plants but no detailed study has yet been made of these. No description of these organisms will be given in this preliminary note, as the writer is engaged in the preparation of a series of longer papers on the subject.

In addition to its intrinsic interest to the protozoologist, the study of this subject may possibly throw new and important light on certain phases of applied pathology. In the first place many plant pathologists are convinced that protozoon-like organisms may be concerned in the etiology of certain obscure diseases of plants. In the second place, there is a close parallel between the relations of these organisms, which are probably primarily insect parasites, to their plant hosts, and the relation of similar insect parasites to their secondary vertebrate hosts. It has already been suggested that plants may serve as the reservoirs of certain human diseases. Franchini has shown that several pathogenic human protozoa will live and grow in latex. He has also succeeded in inducing infection in white rats by inoculating them with protozoa derived from the latex of plants. At the Cincinnatti meeting of the American Association last December, Dr Richard Strong announced that one of these plant parasites, having passed through the body of an insect and a reptile, is capable of parasitizing mammals.

Leptomonas davidi is associated with a definite gummosis of Euphorbia. In none of the plants which I have studied have I be enable to detect any disease symptoms indubitably associated with the presence of protozoa. In most cases the plants are outwardly healthy, and where parasitized plants show disease symptoms a connection between these symptoms and the presence of protozoa has not been established since plants of the same species are found heavily parasitized without showing any lesions.

The organisms apparently pass the winter as minute resting cells, in the stems of shrubs or in the overwintering roots of herbaceous perennials. In two flats of *Hieracium* grown in the greenhouse during the winter, the organism remained in the resting stage in the latex in all parts of the plants. The plants were very robust and healthy but there was no appreciable growth until the approach of spring. With the commencement of growth in the plants the parasites also began to elongate and assume the active condition. Tropical plants growing, in the greenhouse contained active protozoa in their latex throughout the winter. There is evidently then a rhythmic adaptation between the endophytic protozoa and their hosts.

In two cases, *Asclepias syriaca* and *Convolvulus* sepium., the writer has discovered that the organisms, a flagellate and an amoeba respectively, may pass into the seed in the resting stage and later infect the seedling. This, together with the adaptation mentioned in the preceding paragraph and the apparent absence

of injury in at least some cases, points to a long continued association between the protozoa and their plant host.

L. davidi has been shown to complete its life cycle in certain hemipterous insects. Most probably the forms which I am studying are also associated with insects. Preliminary studies have been made but I have not yet succeeded in establishing the identity of the forms studied with any of the numerous flagellates to be found in the insects which attack the infected plants.

THE LIFE HISTORY, HABITS AND CONTROL OF THE LESSER OAK CARPENTER WORM.

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For several years past, the red oaks in certain areas of the Ottawa Valley have been attacked by a destructive, lepidopterous, wood-boring larva, *Prionoxystus macmurtrei* Guer.-Men., commonly known as the Lesser Oak Carpenter Worm, which has caused considerable injury to the trees and been responsible for much loss.

The caterpillar feeds upon the red oak almost entirely, its tunnelling work being carried on extensively within the bark and sapwood, and later on into the inner heart wood of this handsome shade tree, where it takes the form of deep auger-like holes through which rain water and fungous spores often find entrance.

The economic importance of this pest made it of special interest; hence a detailed study of its life-history and habits was considered worth undertaking.

GENERAL PLAN OF WORK AND METHODS

The place where the work was carried out was at Queen's Park, a small wooded area in extent between sixty-five and seventy acres, situated on Lake Deschênes about two miles west of the town of Aylmer, Que., and about ten miles north-west of Ottawa city. The trees in the park for the most part were red oaks, although there was a good supply of bur oak, maple, basswood, blue beech, poplar, birch, cedar, white pine, spruce and balsam. Numerous evidences on all sides pointed to the fact that the Oak Borer had been at work for some considerable time. Many of the trees were badly scarred and showed ugly bulging trunks; others had become rotted at the base; while the majority had larvae working in them, as shown by the fresh piles of saw dust seen around them. The conditions therefore for making this study were vera favourable.

Field work was begun in the autumn of 1918 and continued throughout the summers of 1919 and 1920, supplemented by observations made in 1921 and 1922.

Three main plots were marked off, two for control and the third for life history studies. All trees were numbered. At first, identification tags of cartridge paper were used for this purpose; but these attracted too much public attention and were often as a consequence, torn off by curious visitors. Stencelling the trees in white lead, however, proved quite satisfactory. Large round tobacco tins were used to catch the adults and to collect frass. The bottom of each tin was first removed; sides split up about an inch all around with a shears; the cut parts turned outward at right angles to the sides; the tin then nailed on to the tree over the hole where frass was issuing and the top put on. Banding the trees with wire cloth was found unsatisfactory as the specimens became mutilated on account of entanglement in the netting, and in some cases were destroyed by ants.

The plots were visited daily throughout May and June to determine the date of emergence, obtain adult and pupal records and remove empty skins from the deserted burrows as they were discovered. The larval borings were cleared from the entrance of the tunnels by means of a long-haired brush.

Several experiments in egg deposition under more restricted conditions were carried out at the Divisional Field Laboratory which was situated closed to the park, the results of which appear further on. Notes were kept on the hatching of all eggs, both in the laboratory and in the field, as well as on the habits of young caterpillars and older larvae at work within the wood. During the winter the plots were visited and special trees felled for the purpose of locating the positions of the hibernating larvae and obtaining other data.

A great many photographs were taken; also drawings, charts and tables made, some of which have been used to illustrate the text.

DISTRIBUTION

P. macmurtrei is confined for the most part to Eastern Canada and the Atlantic States but has been taken as far south as Texas. (U. S. Bull. 3, Div. Entom., p. 5.) The western limit appears to be Minnesota.

Its host, as shown from Canadian records is the oak. It has been briefly recorded from chestnut in New York State Museum Report for 1919, on page 516 as follows: "*P. macmurtrei* Guer.—Larva in oak and chestnut," In Fracker's "Classification of Lepidopterous Larvae" on page 78, this short, very indefinite note appears:—"*P. macmurtrei* bores in a number of different trees." Felt, in Memoir 8, N.Y. St., Museum, Vol. 2, page 439, devotes half à page to a description of *P. macmurtrei* and makes the following brief note; "bores in black oak". Apart from these three references, no host other than oak is recorded in the scanty literature available on the subject.

THE HOST TREE

Before beginning a discussion of the bionomics of *P. macmurtrei*, it may be well to give a just brief account of some observations and field notes made by the writer on the characteristics, habits and economic status of the host tree.

The Red Oak, *Quercus rubra* Linn., is a native of Canada and has a range of growth extending from Nova Scotia and New Brunswick to the west of Lake Superior. It is a handsome, straight-trunked tree, branches well and affords good shade. It appears to favour a great variety of soils and conditions,

specimens being found about Aylmer, Que., thriving in low, damp places, as well as on the higher more exposed and rocky localities. It is the most rapid grower of all our oaks and reaches a height of over sixty feet with a diameter usually three feet in extent, and sometimes more. The bark when young is quite smooth, thin and glossy, and will remain so after the tree has attained a considerable size; but as age increases it tends to become cracked and roughened. While slow to leaf in the spring, it will retain all its foliage until late in the fall when the leaves become a brillant red, presenting an object of picturesque beauty not exceeded by any other tree except the red maple, *Acer rubrum* Linn. The leaves are oblong and needle-pointed, with wide oblique sinuses; smooth and firm in texture; a bright pink when first unfolded but turning dark green later. The acorn which is oval and stands about one inch high is inclosed in a shallow cup and is quite bitter to the taste. It requires two years to mature. The wood is reddish in colour, of coarse grain, porous and not very durable; the chief uses being for cooperage, interior finish and the cheaper furniture.

The red oaks have many excellent qualities to commend them for planting on public thoroughfares, on highways of the country side, and on the streets of cities and towns. From a stand point of beauty and shade they are much to be desired. They are also very hardy and grow rapidly under city conditions which often-times are very injurious to tree life, showing a considerable tolerance for such harmful agencies as smoke, gases, dryness and root constriction. They also have the advantage over many other species of *Quercus* in being free, to a considerable extent, from many of the commoner insect pests. In view of these facts it seems strange they are not used more frequently to shade residential streets and beautify the parks and gardens.

There are two species of oak growing in the park; the Red Oak, *Quercus rubra* Linn., and the Bur or Mossy Cup Oak, *Q. macrocarpa* Michx. The former which is in greater abundance than any other tree in the district is well distributed and in fairly good stands. Of these two, the Carpenter Borer attacks the red oak only. This partiality is specially noticeable in certain places where both species are growing side by side. A large number of the trees show injuries directly attributable to the work of the larvae which excavate large areas in the outer bark and tunnel deep holes into the wood. Through these, rain water and fungus spores often find a ready entrance and cause further deterioration of the host. Fortunately, the species possesses quite a remarkable power to recouperate and can quickly repair its injuries, as shown by the numerous healed scars on the trunks and branches. This beneficial characteristic is responsible for many of the trees surviving the severe attacks made upon them. Nevertheless, there is considerable mortality and a large number are in a very poor condition with tops dying downward and branches being killed back gradually.

In several places much coppice growth has been formed. This is another common habit of the species. Groups of three, four, or more trees will be found growing from a common centre so as to form a hollow in which the water settles, creating in this way favourable conditions for the establishment of rots and fungi.

SYSTEMATIC POSITION

The interesting family Cossidae to which this insect belongs, forms a distinct group of the Order of Lepidoptera, the members of which are characterized by the wood-eating habits of the larvae. It includes such well known pests

as the Goat Moths, the Leopard Moths, and the Carpenter Moths. The popular term Carpenter Worm has been applied particularly to the members of the genus *Prionoxystus* because of the very large, augar-like borings that these larvae make in the wood.

The genus *Prionoxystus* is a small but important one containing only two species, *robiniae* and *macmurtrei*. It has been known by other names, such as *Xyleutes*, *Cossus*, etc. That of *Xyleutes*, signifying carpenter, as preposed by Hubner, was certainly a fitting one for the boring larvae. The word *Cossus* has an interesting historic association. It is derived from the Latin form *cossus* meaning "a worm bred in wood".(1) According to Pliny, the historian who was a close student of many branches of natural science, the ancient Romans popularly applied the term *cossus* to an oak borer which they were accustomed to rear for the purpose of food, it being considered by them a highly palatable dish. In the course of his "Natural History" which is an encyclopedic account of the knowledge of his times, Vol. 1, Book 17, Chap. 37, Sec. 4, p. 643, he writes as follows: "Certain trees are infested with worms to a greater or less extent, almost all indeed. And this fact birds test out by the sound of the hollowness of the bark. Indeed nowadays they are beginning to be sought after and the especially large ones from oaks are esteemed a delicacy. They are called cossi and are actually fattened up specially with meal." In another place, Vol. 11, Book 30, Chap. 39, Sec. 3, p. 341, Pliny further records the fact that the Romans also used these borers medicially. This is what he says: "The cossi which are engendered in wood heal all ulcers; they are burnt with an equal weight of anise and daubed on with oil." It is most likely, however, that the word cossus was employed for the first time in scientific literature by Linnaeus in describing the European Goat Moth in 1758, which he named *Bombyx cossus*. . Fabricius, at a later date, 1794, when describing the insect gave it the name *ligniperda*, wood destroyer, and created a new genus on which he bestowed the name *Cossus*. In this genus *macmurtrei* was placed by Guerin in 1829 when he originally figured the lesser-oak carpenter moth. Kirby in his "Catalogue of Lepidoptera" 1892, put it in the genus *Trypanus*, while Neumaegen and Dyer in their "Preliminary Revision of the Bombyces" in 1894 arranged it under the genus *Prionoxystus* which Grote had established in 1882. When Fitch was studying the same insect in 1859 he called it *querciperda* and classified it under the genus *Cossus*. Lintner did the same in 1878. Grote in his new Check List 1882 accepted Fitch's *querciperda* but placed the species under *Prionoxystus*. Barnes and McDunnough in their "Contributions to the Lepidoptera of North America" have classified it under *Prionoxystus macmurtrei* the same as Neumaegen and Dyer. This name is now accepted as the correct one, the others having passed automatically into synonomy.

DESCRIPTION OF THE INSECT.—THE ADULT

The *female* moth is 32 mm. long and 10 mm. at widest part of thorax; with wing expanse of 60mm. It has a spindle-shaped body, rather thinly covered with darkish grey scales and of that peculiar combination of shades known as "pepper and salt". On the mottled fore wings appear black lines running across the principal veins nearly at right angles, while the hind wings are clear, except for a shaded area nearest the body. The head, which is somewhat prominent,

(1) See Ainsworth's English-Latin dictionary 1840 p. 124).

supports a pair of delicate antennae, comb-shaped to the tips. Unlike many of the larger moths, such as the sphinxes that are provided with long tongues and complicated sucking tubes for obtaining their liquid food, the carpenter moths are without mouth parts, or these organs are so atrophied as to be of no use, and food is therefore unnecessary.

The *male* moth is very small being 16mm. long; 6mm. wide and 35 mm. across the wings. It bears little resemblance to its heavy-bodied, lethargic, grey-winged mate, and at first sight may readily be mistaken for some other species. A closer inspection, however, shows it to possess certain characters in common with the female. The head is without mouth parts, the antennae are comb-shaped and small spur-like projections appear on the hind legs. The front wings are clear and shining with only traces of the transverse markings which are so noticeable in the female; while the under pair, for the most part are clear and have the extreme outer margins dark-banded, with a small shaded area on the inner sides nearest the body. Viewed in certain lights a decided sheen can be readily detected on the surfaces.

TECHNICAL

Female. Body length 30 to 32 mm., breadth 8 to 10 mm.

Colour, dull cinereous; head prominent; antennae bipectinate; mouth parts obsolete; thorax well rounded dorsally; vestiture rather sparse, scaly, showing body beneath to be piceous, glaberous and shining; abdomen large, cylindrical and rather thinly covered with grey scales; hind tibial spur reduced; wings translucent, reticulated, primaries crossed transversely by a number of black lines and have their outer margins opaque; frenulum rudimentary; alar expanse 60 mm.

Male. Body length 16 mm., breadth 6 mm.; colour, darker shade than female; slimmer in body proportionately, and shining when scales are removed. Vestiture very sparse; primaries thin, hyaline, with traces of transverse lines; secondaries immaculate, except when viewed from the side, a faint orange-yellow tint is then detected; inner margins dark, outer edges black; alar expanse 30 to 35 mm.

COPULATION

There were several occasions on which mating was observed. On June 14th, 1919—about 9.45 a. m. a large female that had just emerged was noticed at rest about five feet up on the trunk of a red oak. The moth was exposed to the full sunlight and its cream-white two-jointed ovipositor considerably extented. Presently a male appeared quite suddenly. He flew in towards the tree where the female was resting, with a sharp vibrating hum. As he rapidly circled the oak his presence was evidently recognized because the female at once became active and thrusting out her ovipositor further, immediately rejected a quantity of thin, white fluid. The male promptly landed near by upon the bark and with much fluttering of wings rapidly approached and backing formed a union. The female shortly afterwards began to crawl up the bark, dragging the male after her. Unfortunately, the pair came in contact with one of the tin traps used on the trees, and trying to cross the smooth surface lost their foothold and fell to the ground, separating so quickly that it was impossible to secure the male before he got away. The female was placed back

upon the tree and she at once began to oviposit. Some of the eggs were laid upon the smooth bark, others about the edges of the tin, but most were stored away in crevices and cracks, eight, ten and more, tightly wedged together.

There were three or four pairs of moths placed in glass cages at the laboratory for egg records, etc. No evidences of mating were noted in confinement, although the males frequently were active, circling around and keeping up a high beating hum with their thin parchment-like wings, only to be totally ignored or pushed aside. After a day or two the males died, but the females lived for eight or ten days longer to oviposit. Egg records in this connection will be found tabulated below.

Females enclosed in wire cages in the open were frequently visited by males, and several were caught in this way. There were also occasions where males were noticed on the outside of the wire screen of the insectary. Likely they had been attracted there by the females within.

EGG

The egg is somewhat oval in shape, averaging 2.34 mm. in length and 1.78 mm. in width. The whole surface of the chorion is heavily, irregularly reticulated, except at the poles where a small circular area is free from these markings. When first laid they are dull greenish-yellow, but later this colour changes to a full brown with suggestions of a greenish tint in some instances, and in others a dark muddy-yellow.

OVIPOSITION

This begins shortly after the female has emerged from the pupal case. The moth starts by carefully examining the surface of the logs or trunk which it is on, testing every crack and crevice of the bark, and by means of the long ovipositor which is quite freely used, it endeavours to find some convenient spot to place a batch of eggs; then extending the ovipositor deeply into the crevice will pack away two, three, four and even more eggs according to the size of the cavity. In some cases as many as twelve have been counted tightly wedge together. After deposition in one place the moth will move to a fresh site and repeat the operation. Occasionally, it stops awhile as if to rest, then starts up again. A clear viscous liquid is often present in sufficient quantities to moisten small spots on the wood surface. This, is likely, used for glueing the eggs to the bark as it was never noticed except during oviposition. When depressions, crevices or such hiding places are not accessible, eggs may be laid indiscriminately upon the smooth bark, or in small groups more or less irregular in number and scattered.

All the eggs are not expelled at one time: usually a week will cover these activities. The laboratory daily records in this conection show a sharp curve upwards, then a gradual decline. The number of eggs per female varies considerably from 50 to over 275. From two unfertilized females which were dissected, 74 and 132 ova, respectively, were taken in advance stages, with many smaller ones and a number in the early embryonic formations which were not counted.

Dr. James S. Bailey in U. S. Bull. 3, Div. Entom. p. 53 briefly remarks as follows:—"*Cossus robiniae* Peck and *Cossus querciperda* Fitch have been known to extrude upwards of three hundred ova". It may be safe, therefore, to place two hundred and fifty eggs as a fair average per female. The female dies almost at once after oviposition has terminated.

Egg Laying Records.—*P. Macmurtrei.*

Date 1919	Cage 1.	Cage 2.
June	female put in cage at noon oviposition began at 1.30 p.m.	female put in cage at 9 p.m. oviposition began at 11 p.m.
10	68 eggs at 10 p.m.	
11		
12	85 eggs at 6. p.m.	79 eggs at noon.
13		
14		
14		45
15	48	
16		
17	1 female died	42
18	TOTAL DEPOSITION—220	female died TOTAL DEPOSITION—166.
19		
20		
21	Hatching began at 10 a.m.	Hatching began 10 a.m.
22	123 hatched by 7 p.m.	22 hatched by 7 p.m.
23	1	4 hatched by noon.
24	No records taken	No records taken.
25	12	35 at noon.
26	5	4 at noon.

Egg Laying Records.—*P. Macmurtrei.*

Date 1919	Cage 3.	Cage 4.	Cage 5.
10	June female put in cage at 7 p.m. oviposition began in night.		
11	15 eggs at 9 a.m.	female put in cage p.m. oviposition began at 5 p.m.	
15	6	9	
	semale died		
16	TOTAL DEPOSITION—51		
17		1	TOTAL DEPOSITION—125
21	Hatching began		
22	17 hatched by 7 p.m.	61	
		female died	
23	2	TOTAL DEPOSITION—71	
24	No records taken.		

Summary.

CAGE	TOTAL DEPOSITION	
female No. 1	220	
" 2	220	166
" 3	166	51
" 4	71	71
" 5	125	125

Oviposition in Laboratory began June 10
Hatching " " " " 21
Oviposition " Field " " 14
Hatching " " " " 27
Incubation period in Lab. 10 days.
" " " Field 13 "
Average period of deposition 7.5 "

Fig. 1.—Moth. A. Female.—B. Male. Natural Size (Original).

Fig. 2.—Eggs enlarged 14 times (Original).

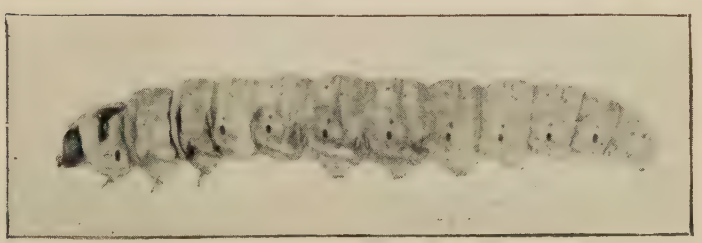

Fig. 3.—Full grown Female Larva (Original).

Fig. 4.—Red Oak Log split to show Larva tunnels (Original).

Fig. 5. Pupa in situ (Original).

HATCHING

A large number of eggs were laid loosely upon the surface of oak sticks placed in cages where the gravid females were confined. The following observations relate to the hatching of these eggs rather than to those deposited in the field.

Incubation occupies ten to thirteen days. When ready to emerge the young larva starts to cut its way out by nibbling a minute opening in the shell. This is enlarged quickly from a small circle to an irregular hole, the larva working at one edge of the aperture. The head is then partly pushed out and the work of cutting away the chorion goes on while the body within is gradually uncoiled, the legs being used vigorously to assist in the process. It is a matter of only a few minutes before sufficient of the shell has been cleared away for the head to emerge entirely, and once this is done the larva proceeds to draw out the rest of its body by short spasmodic struggles, clinging closely to the exterior of the shell as it goes. It now begins to lay down a fine silken thread from the egg case to the bark and at once becomes very active searching for cracks or hollows nearby in which to enter. The time taken to emerge completely, from the moment the first mark on the shell was observed until the larva was outside, averaged twelve minutes.

LARVA

The average larva on hatching is 5.5 mm. long and 1 mm. wide. The head is dark and the thorax dull reddish-brown; the body is flesh coloured on the dorsal side and dull white on the ventral. A number of single, fine hairs appear over the body situated laterally, several of extra length being on the head and anal segment.

By the end of the first season the larva has attained a length of 20 mm. and width 3.5 mm. The head is black and shining, the body pink in colour and marked with a number of tubercles of a darker shade of pink. From each of these a short fine hair arises.

Larvae of the second season show considerable change in length and colour scheme. The following is a description of a larva, likely a female, taken from its 2nd year's hibernating quarters early in April 1921. Length 37.0 mm.; width 6.0 mm.; head dark reddish brown and shining, retractile. Prothoracic shield light brown with transverse crescent markings on the dorsum of the meso-thorax and meta-thorax. Two pairs of hairs on each side of thorax. Abdomen faintly pink, each segment bearing six reddish tubercles, four on the dorsum which are arranged trapezoidally and one on each side near the spiracle. Anal segment brown, true legs reddish brown, tarsi brown with dark hooks; prolegs same colour as body, fringed with red hook-like attachments.

A description of a specimen, probably a male, dug out of its second winter's resting place, on March 1st, 1921, is as follows:— Length 25 mm. approximately; width 5 mm. (broadest part of thorax). Head and mouth parts black, shining, smooth, with few scattered hairs standing erect. Head retracting into thorax. Thorax dull yellowish-brown, the meso--thorax and meta-thorax gradually tapering to meet the first abdominal segment. Each bears a brown lunar marking, the cusps of which point toward the head. Abdomen is bright pink or dorsum, except anal segment which is pale yellow and about the same colour as the venter. Segments are well divided; each has four large, round,

slightly elevated, dark brown tubercles, trapezoidally arranged, situated laterally and above the stigmata, in the centre of each segment, is a brown tubercle; and beneath the stigmatal opening another tubercle, not so well defined. Each of these wart-like bodies has a long, erect, fine, hair 3 to 4 mm. long, those of the final segments are somewhat longer and coarser. The true legs concolorous with venter, are three jointed, with tarsal claws sharp pointed and curved. The prolegs yellowish and fleshy, each with a fringe of reddish-brown crotchets pointing inward. They are situated on the third, fourth, fifth, sixth and tenth, abdominal segments. The breathing spiracles are large and prominent with outer edges coloured brown, placed laterally on each segment of the abdomen, (excepting the last two) about midway, with a tendency cephalad. This is more pronounced in the anterior segments. The prothoracic stigmata are situated well down near the transverse posterior margin of the segment, one on each side.

The full grown female larva is readily recognized by its size. It is a thick fleshy grub, dull greenish-white in color and reaches a length of 65 mm. and width 17 mm. The head is light mahogany and recedes into a hood-like, prothorax which is slightly coloured with brown; mouth parts dark; mandibles large and horny. There is a group of three spines immediately in front of the prothoracic spirale. In first stage larvae, however there are only two in the group. This characteristic is very distinctive of the cossid larvae. Both mesothoracic and meta-thoracic sections have transverse lunar-shaped markings, that of the former being more pronounced. The coloured tubercles so noticeable during the first and second years are now very indistinct. The two spines situated just under each abdominal spiracle are arranged close together; this is peculiar to the genus *Prionoxystus*. The prolegs are large and fleshy, each bearing an oval crown of coral-red crotchets which are arranged in a circle facing inwards. These crotchets are triordinal, that is, they are of three different lengths. The anal segment supports two fleshy processes which have a semi-circular fringe of red crotchets, also triordinal. The heart flow can be very plainly seen beneath the pale skin.

The measurement of a number of head capsules suggests the likelihood of five moults.

Approximate measurements of larvae, according to sex, to indicate the development at end of each season.

Male		Female	
1st season growth from	5 to 15 mm.	1st season growth from	5 to 20 mm.
2nd " " "	15 to 25 mm.	2nd " " "	20 to 45 mm.
3rd " " "	25 to 36 mm.	3rd " " "	45 to 65 mm.

Average Pupal Case for male	—	45 mm.
Average male Larva	—	65 mm.
Average Pupal Case for female	—	25 mm.
Average female Larva approx.	—	36 mm.

LARVAL HABITS

The larva on hatching usually enters the bark at a point just below the egg; but there were instances where this did not occur. Instead, the larvae remained congregated on the surface beneath the batch of empty shells, actively laying down fine webs and exhibiting signs of unrest. This work went on for a day or two and gradually ceased as the larvae burrowed into small crevices near by.

One of the most reliable signs of early larval operations is the presence of small quantities of brown sand-like casting held loosely together by invisible threads of silk. These castings may be found chiefly in the bark crevices and about the creases of callous formations. Another indication is a discoloured spot on the bark, somewhat circular, from a quarter to one half inch in diameter, with a darkened centre from which sap may be oozing.

Thus established the young borer begins slowly to extend the very small cavity, enlarging it slightly as it proceeds inwards through the bark tissues. The space cleared in this way by the end of the summer will be about an inch or so in diameter, depending upon the character of the bark, that of younger trees being softer and more succulent, and the boring itself not deeper than three eighths to one-half of an inch. Here in this small gallery the larva spends the first winter. Next spring, about the early part of May, it begins to extend the site of the first year's operations and not only will bore deeper but also widen its tunnel and chisel it irregularly back and forth in the inner bark and outer layers of wood. Often two or three larvae will be working together in one of these galleries and will clean away and skeletonize an irregular area of several inches across with branch tunnels leading off in various directions. It is during this stage of larval activity that much serious damage is done, large boughs sometimes being girdled and trunks badly disfigured on their surfaces.

As summer progress the larva continues inwards and attacks the outer rings of the sapwood, passing on to the harder material of the heart-wood where it hibernates. One larva dug from its winter quarters was curled in the shape of the letter S, that is, the anterior segments of the body were bent over towards the back, and the posterior ones turned inward over the venter. The creature appeared lifeless when removed, and for some time afterwards, efforts to arouse it were without effect. On bringing it indoors, however, it revived and moved about actively. Other specimens taken from their winter cells in the outer woody rings exhibited this curvature of the body, some showed this more than others, for the most part at the abdominal end.

The following spring, the beginning of the third year period of the larva, the boring operations now having reached the heart-wood are carried further inwards, often with a tendency upwards. After proceeding in this way for an inch or so the larva in many cases will turn and tunnel straight upwards into the very centre of the tree, returning from time to time to the mouth of the tunnel to remove excrement pellets and boring dust, and also to cut back the tunnel walls in order to provide the necessary accommodation for its growing body. By the end of the third summer the entire gallery will be about the same diameter from end to end and excavated to a distance of twelve inches or even more from the point of entry. In September the larva prepares for pupation. In this state it spends its last winter; but if for any reason it should hibernate as a larva, as sometimes happens, emergence will be delayed the next summer.

Occasionally, an exit will become blocked in some unusual way. A pupa endeavouring to reach the exterior will be unable to do so. This contingency

however, will be met when the larva visits the mouth of the tunnel, previous to pupation (as it were to insure that everything is in readiness) and should the passage be blocked it will cut away obstructions and remove all debris, leaving a clear exit for the spined pupa, later to wriggle its way through to freedom. This natural provision while not peculiar to *P. macmurtrei* is note worthy when it is considered that the adult is without mouth parts and helpless to liberate itself in the event of meeting any serious obstruction. During the summer of 1920 two instances of this nature were recorded. It was noticed that the entrance of these particular tunnels had become blocked from the exterior by the natural growth of another tree which had intersected with the host just at the point of entrance. The character of the frass being expelled from narrow slits led to the belief that pupation was to occur soon. Both exit holes were watched with particular interest. One morning soon after the borings had ceased each tunnel entrance was found freshly enlarged, the exterior rims being gouged away clearly as if cut by a sharp penknife and made wide enough to introduce the point of a little finger. This operation took place at night, or early in the morning, and was not witnessed. In due time both pupal cases appeared and the adults were able to free themselves.

It is not an uncommon occurance for larvae to leave their burrows and wander about on the outside, even away from their host. They were observed to do this quite frequently. On one occasion a large grub was found upon the trunk of a white pine about 6 feet up. This nomadic habit which affects both the old and young borers is strange when it is considered that their natural habitat is within the narrow darkened galleries of the tree.

Infested trees often become a good base for further larval operations, forming what are known as "brood trees". Numerous observations lead to the conclusion that once the larvae have become established in a certain tree, some of the following generations will keep to the same oak and use the tunnels made by former occupants to carry on their boring operations deeper and higher up into the heart-wood. Under such an attack the tree is liable to become badly honeycombed and its interior converted into a labyrinth of scoty tunnels which cross and intersect in every direction. On the exterior the tree will heal its wounds by forming thick, horny, bulging scars around the large holes commonly seen on the trunks and which often contain sawdust, frass, rotten wood and other debris. Such conditions offer favourable openings for wood-rotting fungi, and it is not surprising that their spores find a fruitful ground for support and ready propagation.

Borings are often seen near the base of a tree. In cases where infestation has taken place previously in this region, the moth is likely to deposit there again. Usually the female being heavy bodied and clumsy, seems loath to move far from where she originally has emerged until rid of at least part of her burden; she may crawl up the trunk then into the upper branches, or fly to a neighbouring trunk and deposit the remainder of her eggs. The bark at the base is liable to be cracked, particularly in older trees, and show crevices somes distance up the trunk. These offer good locations for oviposition and are readily made use of, no part of the tree may be said to be free from attack, and even the small branches one inch in diameter, have been found intersected with larval burrows. In such, cases, girdling is apt to occur and the branch will break off or become a staghead. The killing back of the upper branches is very characteristic and quite common. Many of the trees have their symmetry completely ruined by these unsightly dead branches and ugly, gnarled, scraggy tips projecting from different parts of the foliage. The larvae also tunnel

Fig. 6. Moths in copula on Red Oak. Tin above for catching adults (Original).

Fig. 7.—Pupae.—A. Lateral view Female Case.—B. Ventral view Female Case.—C. Lateral view Empy Male Case.—D. Dorsal View Empty Female Case (Original).

PLATE IV

Fig. 9.—Pupal Cases, enlarged to show two kinds of spines and other external markings (Original).

8.—Red Oak showing killing back of branches, a typical form of injury by P. macmurtrei (Original).

extensively in the larger boughs, often at the intersections with the main trunk, weakening these to such an extent that they readily crack and break down when swayed by a strong wind.

The following statement shows the number of scars per branch, found on one tree:

Branch.	Diameter.	No. of Larval Scars.	Branch.	Diameter.	No. of Larval Scars.
1	2½	7	7	4	7
2	3	7	8	2½	5
3	1	3	10	1	4
4	½	2	11	2	6
5	3	3	12	3	1
6	1	0	13	1½	3
				2	3
		18			29

Total No. of Scars—47
Average per Branch—3.6

The majority of these wounds were healed over and contained no larvae; judging from the rough chiselled incisions made by woodpeckers it is most likely the birds secured some of the grubs.

Silk Spinning.—Under natural conditions the larva spins its silk throughout the entire boring operations from the time of emergence from the egg until the final stage of pupation.

A young larva placed in a glass vial spun white, cobwebby patches of silk over the surface, almost excluding itself from sight.

The silk is mixed well with the frass in the tunnel, the fine threads holding this material together in clots and loose masses; especially is this noticeable in the pellet and sawdust varieties of castings.

Boring Frass.—Several kinds of boring material are turned out by the larva as it works its way from the outer bark to the wood within. By the character of the frass it expels, the progress or location of the larva within the trunk can be determined with some degree of accuracy. These castings may be described as follows :

1. Fine brown dust grains held loosely by invisible threads, thrown out by the very young larva when starting in a crevice.

2. A dark coloured, sappy matérial produced by the young larva within the outermost layers of the bark, during the early stages of excavation.

3. A dirty mixture of dark coloured and mushy-pulp matter, indicating the larva is entering or working in the sapwood.

4. Dry, white sawdust borings at the tunnel's entrance which have become mixed with coarse, dark pellets and droppings held together loosely by fine threads. This is a fair indication that the larva is excavating within the heart of the tree.

PUPA

The pupa is dark reddish-brown or mahogany coloured. It is well rounded and shining. The eyes, antennae, legs and wings are well seen beneath their thin chitinous coverings, the sutures being clearly defined. The female case averages 45.5mm. in length and 10.8 mm. in width; and the male 24.5 mm. long and 6.0 mm. wide. There is a decided curve ventrally at the posterior end of

the case in both sexes, beginning from segments 6 or 7, the abdominal segments being divided off by well marked sutural lines. These last support an armature of large and small barded processes on the dorsal side, which assist the pupa to reach the exterior. Each segment is divided into three areas, more or less distinct, and arranged as follows :

1. The first or anterior area, rather more thickly chitinized, has a row of coarse, broad-pointed, spear-shaped spines across its posterior border and is set with deep, rather coarse depressions.

2. The second or median area of thinner chitin has a row of fine toothed spines crossing its posterior border and a number of shallow elongated punctures, somewhat scattered.

3. The third or posterior area, a thin and narrow strip adjoining the median caudal border, is covered with a fine reticulation which likely provides for any expansion or contraction of the case.

The spines are placed transversely on the segments and point away from the head. Their arrangement is slightly different in each sex, the male carrying a row of finer spines on the 7th segment, whereas the female is without these. In both sexes the large coarse teeth are fairly regular in outline. The larger of these in each row are situated mid-dorsally and taper off gradually as they pass down, laterally, some distance beneath the spiracular line and in front of the spiracle on all segments except the first three. In segment 1 the entire row is absent; in 2 they terminate just above the spiracle; and in 3 they run to the top of the spiracle. There is a gradual increase in size of the larger dentations from 2 to 9 and also a corresponding irregularity in their form. The spiracles are large and quite prominent in both sexes, those of segment 8 being imperfect. They are tureen-shaped with outer edges smooth and rounded. The basal interior is lined with very fine bristles which when contracted pack together like two hair brushes tightly closing the aperture.

For a detailed study of the principal features of the external morphology of the pupal case of *Prionoxyotus macmurtrei*, by the writer, see 54th Report of Ontario Entomological Society, 1923.

Pupation.

Towards the end of September the larva begins to lay down a soft silk covering over the floor and walls, at the farthest end of the tunnel which has been gouged out and rounded smoothly like the bottom of a test-tube. Having done this it turns about, head outwards, and starts to erect a thick, grey, felt-like curtain, at a point about two inches from the extreme end of the cell, spinning this from the circumference inwards and finally closing same at the centre, thereby completely shutting itself off from the rest of the passage. Here the transformation occurs and winter is spent as a pupa. The following example may be cited here to illustrate the above: An oak was felled on September 29, 1920, and on being cut open, a full grown larva was discovered in the process of constructing its pupal bed. Fortunately, the log split in such a way as to show the whole cell very well. The chamber which was neatly, but rather thinly lined with silk had already been completed and the occupant was busy weaving the felt door which was only half finished at the time it was disturbed.

About the end of May or early in June, when ready to emerge, the pupa breaks through the felt curtain at the cell entrance and by a number of contractions and expansions of the abdomen it begins to move forward on its back out of the pupal bed into the tunnel. In this manner it makes its way along the

passage to the mouth of the burrow where it projects itself sufficiently to expose the head and thorax and perhaps a segment or two of the abdomen. The remainder of the case is held securely within the tunnel walls, anchored there by the numerous, sharp, chitinous dentations which protrude from each segment. Exposed to the air and free now to expand, the case quickly dries and cracks up along the clear-cut furrows enclosing the appendages; then by a number of violent pulsations the head shell splits open and the moth quickly slides out from the case, pulling antennae, wings and legs from their covers, as it goes. The whole operation of emergence takes but a few minutes. As soon as liberated the moth expels a quantity of thick, white, liquid excrement, and crawling lazily on to the bark, proceeds to dry and stretch its wings. These are quite small, flaccid, and much crumpled when at first they come from their covers, but assume their naturel form in about fifteen or twenty minutes. When quite dry and fully stretched the moth folds them tent fashion over the back.

A good example is given here of protective coloration. The dark grey body of the moth, with its mottled wings, resting motionless on the roughened grey bark of the oak presents an object of natural camouflage which may deceive the eye of even a trained observer.

The moths emerge for the most part in June. A careful tabulation was kept of the adults as they came from the trees each day, by collecting the empty cases of the escaped imagines. About two hundred and fifty oaks were under observation and these were visited twice daily, morning and night. The first adult seen and pupal case collected was on June 4. On June 6 and 9 respectively, eight cases were taken, while on the 13th ten were gathered. This number then decreased rapidly until on the 29th one case only was found. Total of moths collected 59, in the proportion of 84.8% females and 15.2% males.

While it is the general rule for pupation to take place in the fall of the year, it would seem that this does not always occur at that period. On two separate occasions transformation did not take place until the following summer. The two particular instances referred to were under close observation and there was good reason to believe that the larvae were shortly to pupate, because the frass which had been observed issuing regularly for the past two seasons now began to be thickly matted and appear in very coarse pellets, a good indication that the tunneller's work was nearing completion. In due time this work ceased altogether and after a brief period of about three weeks both pupal cases appeared.

According to some investigators the larva makes its pupal bed near the mouth of the tunnel and in order to prevent parasites, ants and marauders from finding an entrance, it constructs a crude barracade of chips very near the exit through which the pupa forces its way later. Field observations at Queen's Park for the past three or four years do not confirm this. The habit of forming a barrier of small bits of excelsior cut from the tunnel walls is commonly met with among certain members of the coleopterous larvae, as for example *Saperda calcarata* Say, and *Cyllene robiniae* Forst., but has not been associated with *P. macmurtrei*.

Emergences occurred under cover of night or very early in the morning, a fact which was substantiated by the adults and empty pupal skins being found only during the morning rounds. This arrangement has decided protective advantages, since a wriggling pupa, moth in process of emergence, or one moving

about on the bark in broad daylight may likely run considerable risk of attracting the attention of birds or other enemies near at hand.

METHODS OF CONTROL

Artificial.

Carbon bisulphide was tried as a control measure with satisfactory results. It was sprayed into the tunnels with an atomizer and the entrance holes stopped with damp clay. The plugs were removed with a knife after three or four days, and where no fresh borings appeared it was concluded that the fumes had killed the larvae. Over 95% of the cases thus treated responded satisfactorily.

While carbon bisulphide can be recommended for treatment of single trees, and for use in small parks or along city boulevards, it, necessarily, would be impracticable for control work in extensive forest groves and large areas. Recently, Craighead (1), at Washington, D. C., has found that a lead arsenical.

Some control experiments of this nature were conducted on *P. macmurtrei*, and several materials of different strengths were tried out with various degrees of success. Groups of trees, with their checks, were treated during the summer with solutions of sodium arsenate and lead arsenate, with and without an oil carrier. Carbolic acid, crude petroleum and pyrodene were also employed as ingredients, but were found unsatisfactory for one reason or another. Sodium arsenate proved severe on the foliage, even in small quantities, and was given up for that reason. Lead arsenate in proportion of 3 lbs to 50 galls water without a carrier appeared to have no effect upon the larvae. Even 4 lbs of lead arsenate with a carrier of 1 gal. kerosene emulsion gave only a partial control of 46%; whereas the same spray increased to 5 lbs. resulted in a further 35% of the grubs remaining inactive, making a total of 81% for the last two experiments. Where kerosene emulsion is not obtainable the use of any miscible oil instead will be found ass atisfactory.

Since trees situated in sheltered positions or with a southern exposure appear to be special objects of attack, a careful watch should be kept on such, and where evidences of the borer are noticed, steps taken to eradicate immediately. Very badly infested trees should be cut out and destroyed. This may be done best in the fall or early spring. Such drastic measures, however, are not advisable except as a last resource.

A sharp knife can often be used to good advantage for removing very young larvae from the outer bark. The cut is apt to leave an ugly scar on the trunk if not carefully done; in any case where incisions are made of this kind the wounds should be stopped with grafting wax or painted to prevent infection.

Natural.

Birds.—It is very likely that birds play a most important part in natural control of *P. macmurtrei*. Woodpeckers of different species are seen frequently throughout the summer flying from tree to tree in search of food. It is safe to say that these birds dispose of a large number of young larvae, particularly those of the first year's growth, and since the borers then are not far from the

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(1) Protection from Locust Borer, Prof Paper U S , Dept Agric Bull 787 spray of the usual strengh of 8 lbs to 100 gallons of water has proved beneficia in the control of certain wood-boring species of *Cyllene*, *Goes*, etc The material which is applied with a power-pump, soaks into the bark tissues and incidently about the tunnel entrances When a larva visits the month of the burrow to remove debris, or enlarge the opening for further operations it will eat sufficient of the poisoned bark at the time to kill it The method is a simple and direct one

outer surface of the bark they are readily taken. An inspection of the branches of an infested red oak will convince one of the important role such birds play in the scheme of natural control. Nuthatches, brown creepers, chickadees, warblers and other birds likely destroy many of the eggs. Sometimes the larvae wander over the bark; in this way they expose themselves to the attack of enemies and many no doubt are destroyed.

Parasites.—The only parasite observed was a dipteron which emerged autumn 1922 from a two years old caterpillar taken from a log. Attention was specially called to this larva on account of an abnormal black scar which it was carrying on the dorsum of the thorax. The larva was confined in a tin and died. Shortly afterwards a small gray puparium was found adhering to the tin, close by the withered remains of the host. The specimen was submitted for identifications but on account of its poor condition it could not be determined.

Associated Insects —Ants are often found in and around the tunnels. The large carpenter species, *Camponotus herculaneus* Linn., gets into the heart of the tree by means of the larval burrows and establishes large colonies in the rotting wood, often honey-combing the entire centre of the tree. The carpenter ants bear an interesting commensal relationship with their fellow-workers, the carpenter borers, and while neighbourly do not in any way interfere with the grubs at work, nearby; most likely this is because the ants occupy the discarded burrows and rotted areas, whereas the larvae work in the healthy sound wood.

Injecting carbon bisulphide into infected tunnels will drive the ants out but care should be taken to see that all the holes are plugged before hand, otherwise the fumes will escape and the larvae be left unharmed. Early in June, 1919, one of the trees under observation was badly attacked by borers and ants. There were several large holes at the base through which the ants were working. As soon as the chemical was injected the ants left hurriedly The holes were all plugged, as it was thought at the time, and about two weeks afterwards the trees was cut down. The entire centre was skeletonized into a labyrinth of tunnels. There was no sign of the ants, but the larvae and pupae remained apparently unaffected. An examination showed a number of small holes which had not been stopped, and hence the fumes had escaped, with the above results.

Other arthropods besides ants were found in the tunnels near the entrances, at various times. There were two or three species of centipedes; several species of millipedes; small arachnids, snails, mites, woodlice, and sow-bugs Most of these were attracted, likely by the sapflow, or sought some form of protection within the tunnel's month. Apart from making the observation and securing specimens, nothing worthy of note was recorded of these.

TROPISMS

Mechanical contact.

The larvae are extremely sensitive to touch and will respond immediately to the slightest stimulus, drawing themselves up nervously in jerky movements if interferred with in the least way. Should any of the long erect, hairs on the body be touched or rubbed the larva will assume a defensive attitude rearing itself at once on the prolegs and completely bending back from the first or second abdominal segments so as to bring the head over resting upon the hind part of the body. In this position it will strike back savagely at its aggres-

sor, showing much irritation, at the same time emitting in considerable quantities a dark-coloured liquid of a strong pungent, acetic acid odour. With the ability to move backward quite as readily and swiftly as forward, at the slightest warning of danger it will beat a hasty retreat to the further end of its burrow and remain there motionless. The larva also can reverse its position in the tunnel, if necessary, the largest being able to turn easily within the narrowest confines of its burrow.

Light.

The action of light has a marked effect on both adults and larvae. While the moths would mate and oviposit in the sunshine, they showed an aversion to bright artificial light. Several females confined for egg records at the field laboratory always become much agitated when a light was flashed upon them at night; where previously they were resting quietly, at the approach of the light their wings trembled, antennae and legs moved nervously and a general unrest was exhibited. On removing the light they settled down again.

The very young larvae if in any way exposed to daylight would make every effort to seek cover, persistently shunning the open and hiding beneath their empty shells or any other covering available; in fact the silk webbing always in evidence, was used to form a covering under which the larvae endeavoured to keep themselves sheltered.

Temperature.

Larval activities are influenced by temperature. Certain trees known to have borers working in them were marked in the autumn. The following spring work began before the leaves appeared, and provided the temperature remained about 50°F, the frass would be expelled freely; but if there occurred a drop of 15 or 20 degrees, as frequently happens in late spring, no sign of their work would be found. However, on the rise again of the mercury the boring dust would appear. This response was not immediate, but rather a gradual one.

It was also noticed that the largest number of borings appeared on the warmer sides of the trees, viz; the southeastern, south, and southwestern sides. Isolated oaks, and those more or less in a protected situation, or so located as to receive the sun's rays upon their trunks and branches for the greater part of the day, appeared to be special objects for egg deposition and larval attack.

These preferences would seem to indicate considerable response to thermotropic stimulation by the moth at oviposition and the larvae during boring operations.

Locomotion.

Some simple experiments were tried to determine what effect the surface character of several objects would have on the movement of the moth. It was found that on very smooth material like glass, tin, and polished wood the moth could not walk, even when these were placed horizontally, the legs would be vigorously used but with no result. On paper and on very smooth wood movements were very slow; on coarse or roughened bark progress was normal.

SEASONAL HISTORY.

The moths usually emerge early in June; eggs are laid at once and hatching occurs in 10 days. The first winter is spent in the otter bark, and the second within the inner sapwood. During the third season the larva works in the heartwood, and pupation occurs that fall at the further end of the tunnel. The following June the adults appear. That is to say, larvae hatched, for example in the summer of 1920, will pupate in the fall of 1922 and emerge in the summer of 1923.

SUMMARY

Prionoxystus macmurtrei Guerin-Menville, commonly known as the Lesser Carpenter Worm, is a wood-boring, lepidopterous larva which tunnels in red oak *Quercus rubra*, and is confined in range chiefly to the eastern parts of Canada and the United States. It will do great damage if allowed to remain and breed for several years in the same stand, large trees being completely ruined by its persistant attacks. Wood-destroying ants and rotting fungi often accompany the borer's injuries. These harmful agencies working within the trunk break down the woody tissus, reduce them to a rotten, honeycombed mass and hasten the destruction of the host. The appearance of sawdust piles or small pellets of frass about the base of an oak forms a safe index to the presence of the borer. Another reliable guide is the swollen canker-like growths appearing on the trunks of the older trees which have been infested for several seasons. These are induced by the tree itself in its endeavour to heal the wounds made by the larvae. Broken down branches and stag-headed trees also supply reliable clues. This form of injury is perhaps the most common and most noticeable.

The female moth resembles in many respects its widely known and more destructive near relative, *P. robiniae*, but may readily be distinguished from it by the numerous black lines which cross the fore wings, *transversely;* whereas the very small male differs considerably from *P. robiniae*, in size outline and colour.

Eggs are laid in June in the crevices of the bark, one female being capable of depositing as many as two hundred and fifty or more. Hatching begins in ten days.

The larvae take three seasons to mature and attain a length of two and a half inches, in the female. They burrow into the outer layers of the bark where they spend their first season. The next year they continue their tunnelling into the sapwood, passing the second winter in a somewhat bent or curved position within the tunnel. During the third year, boring is entirely within the woody parts of the tree and this work is carried on until September when preparations for pupation begin. The transformation takes place in a silk-lined cell at the further end of the tunnel and the moths emerge the next summer early in June. Occasionally, pupation is delayed till the following Spring, and in such a case the emergence will also be later.

Carbon bisulphide injected into the tunnels, which should be plugged at once, is a successful means of control, and may be used to good advantage in small areas. For extensive areas as in large parks, along highways, and forest lands, the following strong arsenical mixture will be found satisfactory:

5 lbs, lead arsenate.
40 galls, water
½ gal. kerosene emulsion or miscible oil.

This should be carefully sprayed into the exit holes and wherever there are indications of larvae working.

Birds, especially those of the woodpecker species, form an important factor in natural control. Their presence in parks and gardens should be more encouraged, and their safety and protection assured by well enforced legislation. Parasites would seem to play little part in natural control.

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A FRUIT WORM (*GRAPTOLITHA LATICINEREA* GROTE) AND ITS CONTROL

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In 1915, *Graptolitha bethunei* G. & R. was present in all the apple orchards of Huntingdon county and damaged as much as 75% of the crop in some orchards. In 1922, the Saddled Prominent (*Heterocampa guttivitta*) defoliated the sugar maples at Franklin Centre over an area of four square miles. In 1923, *Graptolitha laticinerea* defoliated a large number of trees at Cartierville and it was much more destructive on Isle Bizard. Thus almost every year in this

province there are local insect outbreaks by casual pests, which cause very intensive injury.

On June 26th, 1923, along the shore of the Riviere des Prairies the trees were considerably defoliated, and directly opposite on Isle Bizard defoliation was almost complete. The caterpillars were found in numbers on many kinds of trees and shrubs and the presence of injury proved it to be quite a general feeder. The elms, maples and dogwoods were the most seriously injured but apple, soft maple, chestnut and several other trees were injured to a lesser degree. Trees in the open or windswept locations are usually only slightly attacked but in sheltered areas the pest is most important.

The caterpillars were in the last instar and measured from one and one-quarter to one and two-fifths inches in length. The head and mouthparts were light, shiny green, except for the black or brownish tips of the mandibles. The general body colour was apple green and there were dorsal and lateral continuous, broad, white stripes. Tubercles all white and the spiracles surrounded by a black ring. The prolegs and thoracic feet were of the general body colour. The general body colour was sometimes creamy or pinkish, probably the result of the food plant upon which they had been feeding. Several of the larvae were caged and supplied with apple foliage. After a short period they pupated and adults emerged in September. They were submitted to Dr. McDunnough, Entomological Branch, Ottawa, and determined as *Graptolitha laticinerea* Grote. Sanders (1) observed in 1913 that the fifth and sixth stage larvae of *Graptolitha bethunei* G. & R., a closely related species, was predaceous on the pupae of the tent caterpillars (*Malacosoma disstria* and *M. americana*).

The egg is dome-shaped and laid singly on the underside of the tips of the outer branches. Many of the eggs are deposited at the base of the buds or on bud scales and when in the latter position they often drop to the ground before the larva emerges. Pupation takes place during July from two to four inches below the surface. The pupa is naked, yellowish-brown and three-quarters of an inch in length. The adult is a dull coloured, grayish moth, with inconspicious markings and one and one-quarter inches wide, when the wings are expanded. They are strong fliers and are on the wing for a month in the fall and another month in the spring. According to Slingerland (2) they are, "often found in maple groves while sugaring is going on. Sometimes sap pails are found in the morning, completely covered with moths."

Remedies,

According to Slingerland and Crosby (3) they should receive the following treatment. As the green fruit worms are about half grown when they begin feeding on the fruit it is then a very difficult matter to kill them with a poison spray. Earlier when feeding on the buds and newly opened leaves many of the

1.—Sanders & Dustan, Dom. Can., ept. Agr. ,Ento,m Bul. 17, p. 13.
2.—Sanders & Dustan. L.C. p. 8.
3.—Slingerland & Crosby, Manual of Fruit Insects,p. 41.

young worms could doubtless be destroyed by a thorough application of arsenate of lead, 2½ or 3 lbs. in 40 gals. of water or dilute lime sulphur solution.

Sanders and Dustan (1) offer the following advice. The height of emergence takes place when the blossoms are showing pink. Therefore, in serious outbreaks the spray should be applied just before the blossoming period. The calyx spray is also important and in both applications high velocity, drenching sprays should be applied. Arsenate of lead 5 lbs. to 40 gals. of water or dilute lime sulphur solution is the most satisfactory mixture.

According to Sanders and Dustan, (2) "The most important natural means of control are wind and rain which cause immense numbers of the larvae to drop to the ground and perish during the first two weeks of their existence".

THE STRIPE OR STREAK DISEASE OF TOMATOES IN QUEBEC.

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Introduction.

Early in the spring of 1923 the tomato crop in the commercial greenhouses at Macdonald College became infested with a disease which was characterised by a long spindling growth of the upper part of the plants, a spotting, curling and shrivelling of the leaves, small irregular brown spots on the fruit, and brown, oblong, sunken markings on the stem and petioles.

On examining the literature it was found that the disease resembled most closely one which has been reported on under a variety of names, and concerning which investigators differ in their opinion as to the etiology.

Previous Investigations.

The first account of such a disease was given by Bailey (1), in 1892, when he reported a blight of winter tomatoes which corresponds in many details with the outbreak here in Quebec, except that he found no spotting on the fruit. To this he ascribes the name "Winter Blight of Tomatoes". He was unable to determine the specific cause of the malady.

Five years later Selby (2), from Ohio, described a blight of forced tomatoes with symptoms similar to those described by Bailey, but he reports a spotting on the fruit. He was unable to find any organism associated with the diseased tissue; whereas Bailey mentions that a micrococcus was found in the diseased parts.

In 1916, the disease was first reported from Canada by Howitt and Stone (4). Repeated trials to isolate a causal organism from the diseased tissues

1.—Sanders & Dustan, Loc. cit. p. 15.
2.—Sanders and Dustan, Loc. Cit. p. 16.

proved futile. From carefully conducted experiments these investigators suggest that the cause of the trouble lies in the soil.

C. R. Orton has also reported the disease from Pennsylvania.

In 1919, Paine and Bewley (5) reported a disease of tomatoes, with apparently identical symptoms with those described above, as being present in England and the Channel Islands. These investigators were able to isolate a bacillus, which they later identified as *Bacillus lathyri*, from diseased tissue, and with it they could bring about artificial infection.

Schroevers in 1922, mentions stripe disease of tomatoes as occuring in Holland, and Taylor in 1923, reports it from New Zealand.

Gardner and Kendrick (6) in an article on tomato mosaic published in 1922 from Indiana, are of the opinion that the diseases described by Bailey of Cornell and Selby of Ohio, as well as those reported from Pennsylvania and Ontario, are mosaic in its most destructive from. They state that "it seems very likely that many of the puzzling greenhouse tomato diseases or winter blights reported in literature were merely different manifestations of mosaic."

B. T. Dickson reported it from Macdonald College in 1923, this being the first time that the disease was reported from the Province of Quebec. Professor Dickson inclines to the view that it is a mosaic in which Necrosis occurs under certain environmental conditions.

Since there is still some doubt as to the actual cause of this so-called stripe or streak disease of tomatoes, it was decided to investigate the problem, and Mr. J. K. Richardson, M. Sc. began a study of the disease in 1923 under Quebec conditions. The disease was carried over the summer of 1923 on tomato plants in the field. Healthy plants were inoculated by rubbing their leaves with crushed leaves and petioles of diseased plants.

In the early spring of 1924, at the suggestion of Dr. Dickson, the writer undertook to carry on the investigations in the experimental greenhouses and plots at Macdonald College.

It was thought advisable to make a progress report at this meeting of the Quebec Society for the Protection of Plants, especially as it is the first time that work is being done on the disease in this province.

Symptoms of the Disease.

An attempt to describe in detail a set of clear-cut symptoms of the stripe disease of tomato, would necessarily be inadequate because of the various forms which the disease takes depending apparently upon the succulence and age of the plant, as well as upon the temperature, illumination, etc. Therefore the general symptoms will be given with here and there variations from the general type which are often quite characteristic.

At Stage of Infection.

Ordinarily the disease is first noticed on the tomato plants about the time the first blossom truss appears, and necrotic streaks occur in a zone about a

foot in extent two-thirds up the plant. Here the leaves begin to show irregular yellow spots which subsequently turn brown and finally quite dark, being still surrounded by yellowish areas. Later complete necrosis with wilt and drying out occurs.

The upper growth becomes spindling and distorted, (Plate II) the leaves small and weak with numerous yellowed and minute necrotic areas. As one looks down the rows between the greenhouse tomato beds the spindling growth of the upper part of the plants is very prominent. Infected plants usually linger on in this condition for several weeks, but rarely there is complete wilting of the whole plant — following on curling and shrivelling up of the leaves.

Immediately below the diseased zone there are on the average eight to ten strong, healthy lower leaves. These seldom show lesions, but the shoots which may arise from the exils of these leaves show typical symptoms.

The necrotic areas on the leaves do not usually conform to any definite arrangement, but any one of the three following types may be observed: First, the speckling may fellow the veins more or less; secondly, the specks may be grouped together — many having coalesced — on both sides of the main vein at the end of the leaf nearest the stem, or thirdly, the specks may be grouped together on both sides of the main vein and extending to the edges and tip of the leaf.

In the diseased zone, brown, sunken, oblong stripes or splashes are found on the stems (Fig. 1) petioles, flower stalks and calyces. These streaks occur simultaneously with the specks on the leaf laminas, as a rule.

No yellow streaking has been observed on the stems, as is the case with the leaves, but the lesions appear brown from the first. These are linear, varying in size from one millimeter to several centimeters in length; they enlarge and often coalesce, although this last is a very variable condition. The larger lesions on the petioles have a more water-soaked and sunken appearance than those on the stem. They gradually enlarge, eventually causing the petiole to shrivel, turn brown, and dry out backwards with the leaflets hanging dry and dead.

The lesions on the sepals are relatively small and not elongated.

On the fruit are found dark brown, shiny, sunken, irregularly shaped patches, with no definite arrangement. (Fig. 2) In the initiation stage these appear to be greenish brown, but both types occur on the fruit at the same time. They may occur anywhere on the fruit, although in one type they seem to be confined to the stem end. The largest of the patches, produced by coalescence of the smaller ones, frequently possess one or more cracks or slits produced by drying out. Severely affected fruit tend to be deformed.

An examination of the roots both externally and internally reveals no apparent divergence from the roots of a normal plant, except that perhaps the root system is somewhat reduced.

Frequently plants are found which show a superficial bronzing on the leaves in the necrotic zone. On examining these either with a pocket lense or

Fig. 1.—Stripe lesions on stem of tomato from south house (Fig. 3).

Fig. 2.—Characteristic lesions on fruit.

PLATE I

PLATE II

Type of growth of a diseased plant. A to B healthy, B to C zone showing stripe lesions in stem, petioles (1) and leaves with leaves shrivelling and dying later (2), C to top straggly, spindling and weak stem, deformed leaves with symptoms of mosaic and occasional stripe lesions.

under the microscope, it is found that the multicellular ends of the glandular hairs are all dark brown. Furthermore, these structures are considerably more numerous on diseased than on healthy plants, on which last the trichomes are green in colour.

One observation worthy of note is that all the tomato plants here at Macdonald College infested with stripe also had mosaic. In many cases the mosaic symptoms were not clearly apparent at first; but the characteristic symptoms always developed later, the light green and dark green patches being distinctly clear cut.

Some Internal Symptoms.

(*1*) *The stem.*—Cross sections of diseases stems show that usually the brown lesions are only superficial, but in some, the necrosis extends well into the cortex, and in others again, the pith is invaded as well. The vascular elements do not show any definite symptoms of necrosis. Longitudinal sections taken at the junction of the petiole with the stem show that the necrotic tissue leads from the one into the other, either by the cortex, or by the pith or by both. Small brown patches are also found in the pith and cortex.

(*2*) *The petiole.*—Internal symptoms are similar to those of the stem; but the extent of the internal browning ranges from lesions including the epidermis and a few layers of cells of the cortical tissue to cases where the whole petiole is necrotic — all the tissues being affected. The course of the brown area can be traced from the cortex into the pith, the vascular elements being unaffected in the majority of cases.

(*3*) *The leaves.*—All the tissues of the leaf except the vascular bundles become necrotic. There is a shrivelling and drying up of the lamina in affected areas and here the walls are quite brown. The cells in such areas and those closely adjoining appear to be completely collapsed and desiccated. Such tissue stains very deeply with Gentian Violet and Carbol Fuchsin. It cannot be definitely stated that bacteria are or are not present; for, on the borders of some lesions short rods which have taken the stain deeper than the surrounding material, are observed in small numbers. If they are bacteria, they are far fewer in number than is commonly the case in plants attacked by bacteria and they may be secondary in the lesions.

Enlarged nuclei are often found in cells adjoining necrotic lesions. Affected leaves are found to possess an abnormal number of cells containing shining crystalline deposits which will not stain.

(*4*) *The fruit.*—The spots on the fruit are usually superficial and include only a few layers of cells. Occasionally brown streaks and patches of tissue are noticed interspersed here and there within the fruit.

(*5*) *The roots.*—The roots from twelve severely diseased plants were examined by cutting longitudinally and transversely but no indications of the presence of bacteria were observed in any case.

Paine and Bewley (5) on the contrary found organisms in the roots and consider that infection is possible from the root up into the plant.

Distribution of Stripe in Greenhouse.

From a study of the South House, (Fig. 3), it is clearly seen that the outer rows in each bed where the disease occur are much more heavily infested than the inner rows. In a conversation with Mr William A. Ross, Entomologist-in-charge at the Vineland Station, Ontario, he remarked that he had observed a similar distribution of the disease in greenhouses near London, Ontario. In the North House where there were only a few diseased plants when the count was taken, these occured on the outside rows only; the two rows on the inside in every case being entirely free from the disease. A count of the south house shows that of 213 diseased plants, 135 were on outside rows and 78 on inside.

From the foregoing it might be inferred that the disease is probably transmitted by the greenhouse attendant both when watering the plants, disbudding or pollinating them. Incidentally, it might be mentioned that the tomato crop in the two houses shown above was a complete failure.

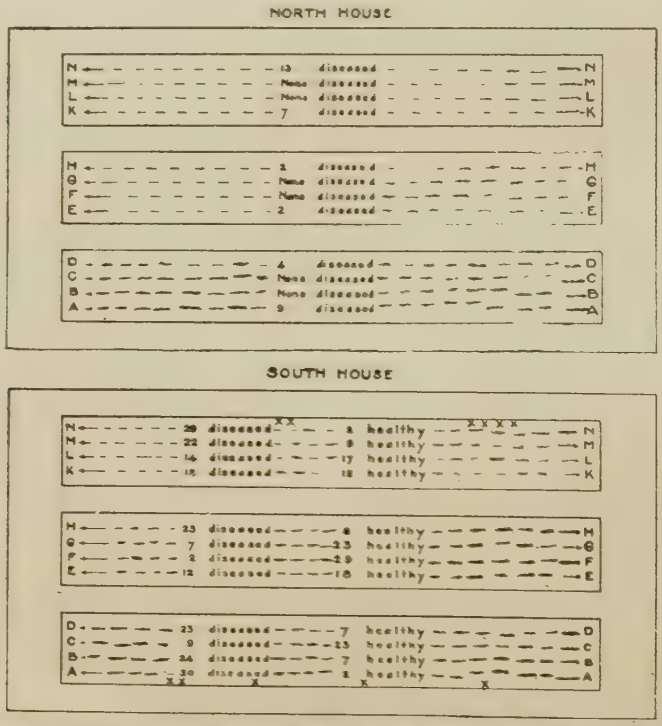

Fig. 3.—Plan of green houses showing distribution of stripe disease of tomatoes. First plants at X on March 12. Count taken April 5, 1923.

Experimental Work To Date.

Isolations.—Numerous attempts to isolate a causal organism from diseased tissue were made, and in a few cases — the majority being from internal stem lesions — a yellow motile organism was obtained. This was cultured on nutrient and potato agars and in beef bouillon, and the following preliminary inoculation experiments made:

Series 1.—The organism was inserted, under sterile conditions as far as possible, in a slit in the stem of healthy tomato, potato, tobacco, sweet pea and broad bean plants; the stem carefully wrapped with tin foil, and the plants placed under large bell jars. This experiment was duplicated, and cultures of a yellow organism isolated at different times were also used, but in every case the results were negative.

Series 2.—The organism was sprayed on healthy tomato, potato, tobacco, sweet pea and broad bean plants, both wounded and unwounded; and as before no disease symptoms were produced.

Series 3.—The series of experiments tabulated below were carried out by Dr Dickson in 1923;

Plant.	Inoculum used	Date of Inoculation	Appearance of first lesions.	Incubation period.
1. Tomato.	Crushed leaflet rubbed.	March 24th.	April 3rd.	10 days.
2. Tomato.	Cortex inserted.	April 6th.	April 16th.	10 days.
3. Tomato.	Yellow organism rubbed.	April 6th.	April 16th.	10 days.
4. Tomato.	Yellow organism rubbed.	April 6th.	April 16th.	10 days.
5. Tomato.	Scraping inserted.	April 6th.	April 16th.	10 days
6. Tomato.	Insertion.	April 7th.	April 19th.	12 days.
7. Tomato.	Insertion.	April 10th.	April 18th.	8 days.
8. Tomato.	Scraping inserted.	April 11th.	April 30th.	19 days.
9. Tomato.	Pith inserted.	April 28th.	May 9th.	11 days.
10. Tomato.	Pith inserted.	April 28th.	May 9th.	11 days.

From a study of the table, it is interesting to note that, with the exception of plant No. 8, the time between inoculation and the first appearance of symptoms, is about 10 days. In this connection it might be noted that this is the time taken for tomato mosaic to develop. Also, that the organism used on plants Nos. 3 and 4 was an original culture from necrotic tissue implanted on a nutrient agar slope. First and subsequent subcultures of the yellow organism from this tube failed to produce the disease on healthy tomato plants later.

Series 4.—In April 1924, the writer inserted diseased tomato tissue into healthy plants of potato, sweet pea and broad bean and covered the wound with tin foil. No positive results were obtained.

In continuing experiments in the greenhouse this winter it was found that the easiest way to transmit the disease was by rubbing the leaves of healthy plants with crushed tissue of diseased plants.

Series 5.—The two sets of experiments outlined below demonstrate the difference in the length of incubation period depending apparently on the temperature. Although one set of experiments were conducted in the field and the other in the greenhouse, I think that they are nevertheless comparative inasmuch as the inoculations were made at blossoming time — when the plants were in as near the same conditions physiologically as the differences in environment would permit. There is, of course, the possibility of a difference in virulence or in amount of inoculum.

Experiment 1.—By Dr. Dickson: Four plants in the field were inoculated by rubbing with diseased tissue from greenhouse plants on July 20th, 1 23. On August 1st, lesions appeared in young leaves, petioles and stems. That is, there was an incubation period of 11 days.

Experiment 2.—In an experiment conducted by the writer, four plants in the greenhouse were inoculated by rubbing with diseased tissue on February 22nd, 1924. The greenhouse was kept at a temperature of 48–50°F.

Results: One plant showed first symptoms of streaking on stems and petioles and specking on the young leaves 18 days after inoculation. Plant 2, showed first symptoms 22 days after inoculation; plant 3, 25 days after, and plant 4, 27 days after. Checks remained healthy.

From these experiments it might be inferred that a temperature as low as 50°F lengthens the incubation period as compared with summer temperature.

Series 6.—When healthy tobacco plants are inoculated by rubbing with striped tomato plants, only mosaic symptoms are produced; that is, no specks or splashes develop. In this connection the following experiments are of interest.

1. A healthy tomato plant was inoculated by rubbing with crushed leaves of a tobacco plant having mosaic. This plant contracted the stripe disease, the lesions being very small, however.

2. Stripe disease was also produced on tomatoes in the greenhouse rubbing with mosaic tissue from Resistant White Burley tobacco. It must, however, be noted that the tomato plants in both experiments were uncovered, so that the possibility of transmission of the disease from one of the other diseased plants in the same field or greenhouse, was possible. Therefore, a repetition of this experiment under controlled conditions is necessary. This is being carried out at the present time.

It is interesting to note that Clinton (3), in 1907, performed the following experiment amongst others :—

"Exp. 28. Nov. 11, tomato plant was crushed after crushing fresh leaves of calicoed tobacco in hands. Nov. 25, young leaves and stem showed elongated, irregular, discoloured streaks or burns, like a bacterial disease, but no true calico-like appearance. Check plants showed no similar trouble. Jan. 8, plant dead of wilt, but before dying, some leaves showed signs of true calico. The bacterial-like burn of the leaves, however, was the conspicuous trouble."

As has been previously stated this is a progress report and further experiments in the field on tomato, potato, tobacco and other Solanaceous plants are being carried out on a large scale this summer.

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CULTURAL CHARACTERISTICS OF CERTAIN COLLETOTRICHUM SPECIES.

by

G. A. SCOTT, B.S.A., M. Sc.

Introduction.

Among the fungi, one of the most important groups is that which includes the "anthracnose organisms", that is to say, the Colletotrichums and Gloeosporiums, the Volutellas and Vermicularias with the perfect stages of such of these as are known. As a group it has received considerable attention from the point of view of Morphology, Cytology, Physiology, Taxonomy, Pathogenicity, etc.

The study reported here was suggested by Dr. B. T. Dickson, Head of the Department of Botany, Macdonald College of McGill University and was undertaken by the writer while holding a Macdonald Scholarship for 1923-24.

During the last few years attention has been drawn to diseases of potatoes variously known as "Dartrose", "Black Dot", "Foot Rot", "Anthracnose", etc. The diseases have been described from France, England, Canada and the United States of America. From published descriptions there appeared to be sufficient similarity in symptoms to warrant a study of the causal organisms in order to determine their relationship. The present paper is concerned with the cultural characteristics of the organisms on various media, and, at the same time with certain morphological characteristics which were considered of sufficient importance to form the basis of comparison.

Historical Review.

In 1908 Ducomet published an account of a new potato disease occuring in France which he called "Dartrose". This he ascribed to *Vermicularia varians* sp., nov., which organism he stated was an "Espece variable, évoluant vers les Phoma ou inversement vers les Colletotrichum et Glocosporium".

O'Gara in 1915 reported a new species of Colletotrichum on potato which he found in the Salt Lake Valley, Utah. He considers it related to Vermicularia and named it *Colletotrichum solanicolum.*

Taubenhaus in 1916 in his studies of silver scurf of potato described a Colletotrichum which he regards as identical with O'Gara's organism but which on a basis of priority he calls *Colletotrichum atramentarium.*

Pethybridge reported a similar disease from Ireland in 1918 and in studying the organism came to the conclusion that it should be called *Colletotrichum tabificum.*

Dickson in 1921 found a black dot disease to be quite common in Quebec and the organism concerned appeared to be identical with that described by Ducomet except that no pycnidia were ever found.

Organisms used.

In this study the following organisms were used.

1. The isolation from Canadian material herein called the *Quebec organism.*
2. The saltation from No. 1. (see Dickson 23), herein called the *Saltation.*
3. *Vermicularia varians.* Ducomet.
4. *Colletotrichum tabificum.* (Hallier p. p.) Pethybridge.
5. *Colletotrichum atramentarium.* (O'Gara) Taubenhaus.
6. *Colletotrichum atrovirens.* (?).

Source of the cultures.

All the above cultures were turned over to the writer by Dr. Dickson who states that he obtained them as follows:

1. *Quebec organism.*
   Culture made by Dr. Dickson from Quebec material.
2. *Saltation.*
   Culture made by Dr. Dickson from *Quebec organism.*
3. *Vermicularia varians.*
   Subculture made from a culture of Dr. Pethybridge made in turn from one by M. Cavadas from French material.
4. *Colletotrichum tabificum.*
   Culture made by Dr. Dickson from potato material sent by Dr. Pethybridge.
5. *Colletotrichum atramentarium.*
   Subculture made from a culture sent to Dr. Dickson and made from Ohio material by Dr. Freda Detmers.

6. *Colletotrichum atrovirens.*
Culture sent by Dr. N. J. Giddings of the Laboratory of Plant Pathology of the West Virginia Agricultural Experiment Station at Morgantown, W. Va. The writer has not been able to find any published technical description of this organism.

Media used.

Since one of the main objects of this investigation has been a carefull study of the cultural variations of the above organism, as large and as varied a number of media as time warranted were used. The media falls, naturally, into two classes *solid* and *liquid*. The first class consists for the most part of plant media and nutrient media made with agar. In the second group is a number of well-known nutrient solutions.

Cultures were grown in tubes of different sizes, in 150 cc. Pyrex Erlenmeyer flasks and in petri dishes. All glassware was thoroughly washed in tap water, rinsed in distilled water and autoclaved for twenty minutes at fifteen pounds pressure before it was used. This method proved satisfactory and very little contamination resulted.

Of the solid and liquid media used the following were found to be the most suitable:—

Solid 1. Potato-dextrose agar.
2. Czapek's synthetic agar.
3. Oatmeal agar.
4. Cornmeal agar.

Liquid 1. Currie's solution.
2. Pfeffer's solution.
3. Czapek's synthetic solution.
4. Duggar's synthetic solution.

"Merck" chemicals were used entirely in the preparations of the liquid media.

Observation on type and rate of growth.

On solid media.

On the solid media used growth characteristics were so similar that the writer will not give individual descriptions. With the exception of the *Saltation*, the general type of growth was as follows :

The first indication on the medium was the production of a white downy to downy silky, superficial mycelium. No coloration was observed until about the end of the fourth day when a distinct amethyst color, most prominent in the centre of the culture, began to appear. This amethyst coloration is a striking general characteristic of all the cultures. In a few plates a yellow coloration was also noted. At the end of the sixth day black sclerotia appeared on the surface of the agar and the white superficial mycelial growth began to disappear. The sclerotia are almost invariably produced in concentric rings in petri dish cultu-

res. Contrary to the findings of Ducomet ('08), pycnidia were not found in any of the cultures. On Czapek's and cornmeal the sclerotia are more distinct than on potato-dextrose or oatmeal. On the latter two, the sclerotia are massed together and do not appear individually to such an extent. On cornmeal there is sometimes a distance of an eighth of an inch between two sclerotia. On old cultures where a large number of conidia have been produced, the surface layer will again be covered by a superficial layer of white mycelium, produced no doubt by the germination of the conidia.

In the case of the *Saltation* no sclerotia were developed at all. The amethyst color was discernible in all the cultures but the predominating color was yellow. Conidia were produced very luxuriantly in all cultures. On close examination it appeared that each conidiophore always bears a conidium at its tip and others are found lower down. After the first falls others are developed in the same place.

The results of microscopic examinations of conidia are given in the following table;

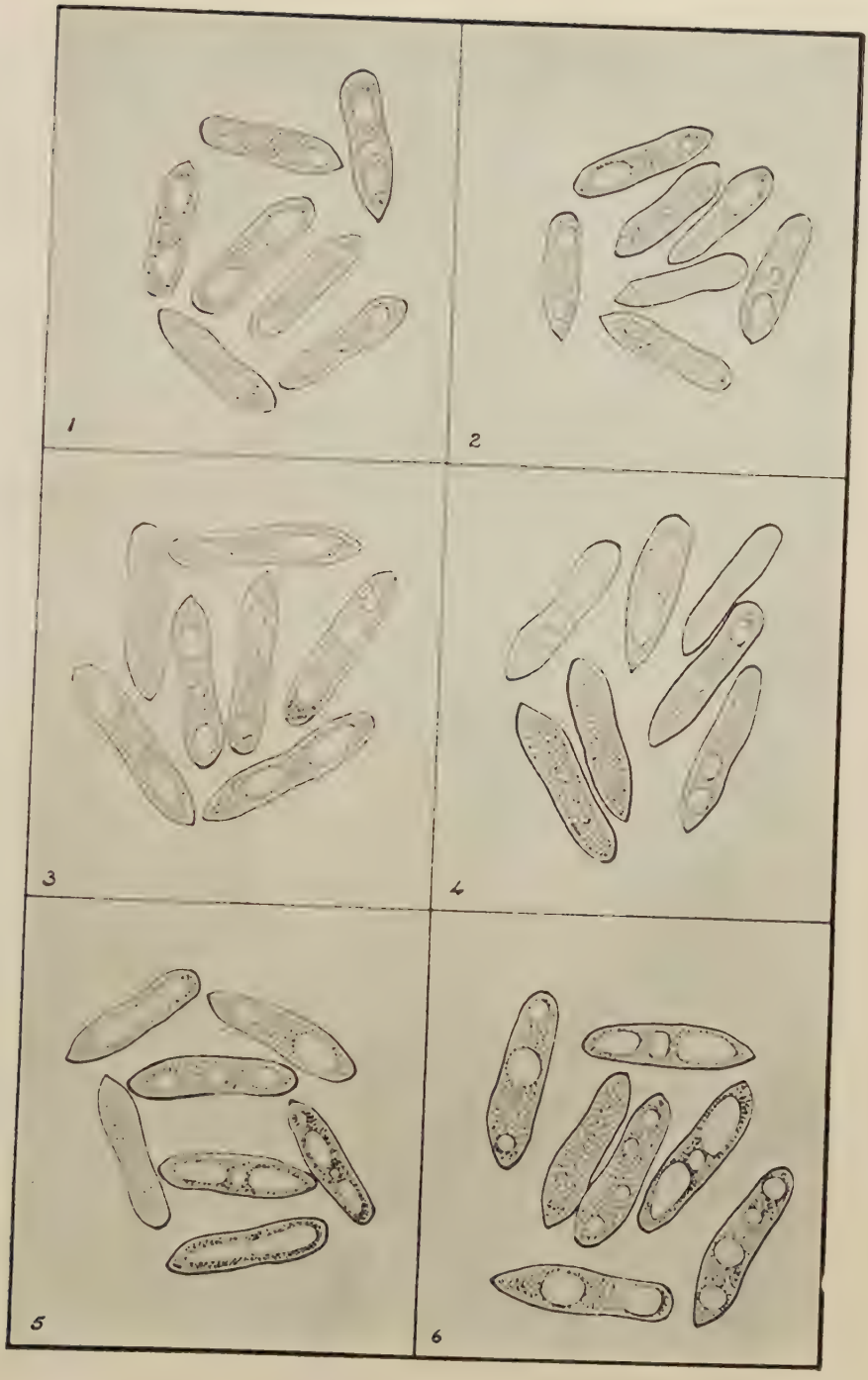
Spores.

Org.	Lenght.	Width.	Color in mass.	Guttulation.
Que. org.	17.8 – 20.7u	3.0 – 3.7u	pink.	1 – 3.
Saltation.	17.5 – 19.7u	3.0 – 3.8u	yellow.	1 – 3.
V. varians.	18.0 – 20.6u	3.5 – 3.7u	pink.	1 – 3.
C tabif.	19.1 – 20.8u	3.0 – 3.7u	pink.	1 – 3.
C. stram.	17.5 - 19.6u	5.0 —3.9u	pink.	1 – 3.
C. atrov.	16.5 – 18.8u	5.4 – 5.7u	pink.	1 – 3.

The spores vary in size to an appreciable extent. The above measurements are the average of a large number of determinations. In shape they are identical being continuous, cylindrical, slightly pointed at the basal end and rounded at the apical end. Some are slightly curved and restricted at the middle. The number of guttules varies from 1–3. In a few conidia there are 4 guttules but that is an exception. The presence or absence of guttules seems to be governed by the factors of age and nutrition.

The mycelium is septate in all cases. The cells vary in size to a marked extent. The vegetative cells are cylindrical in shape while the sclerotial cells are more or less rounded to barrel shaped.

As stated above, sclerotia appeared in all cultures with the exception of the *Saltation*. They were oval to round in shape, black in color, and varied in size from a very minute mass of black mycelium to a well defined body that could easily be distinguished with the naked eye. The term sclerotium is here used to include the small black mass of mycelium with or without setae.

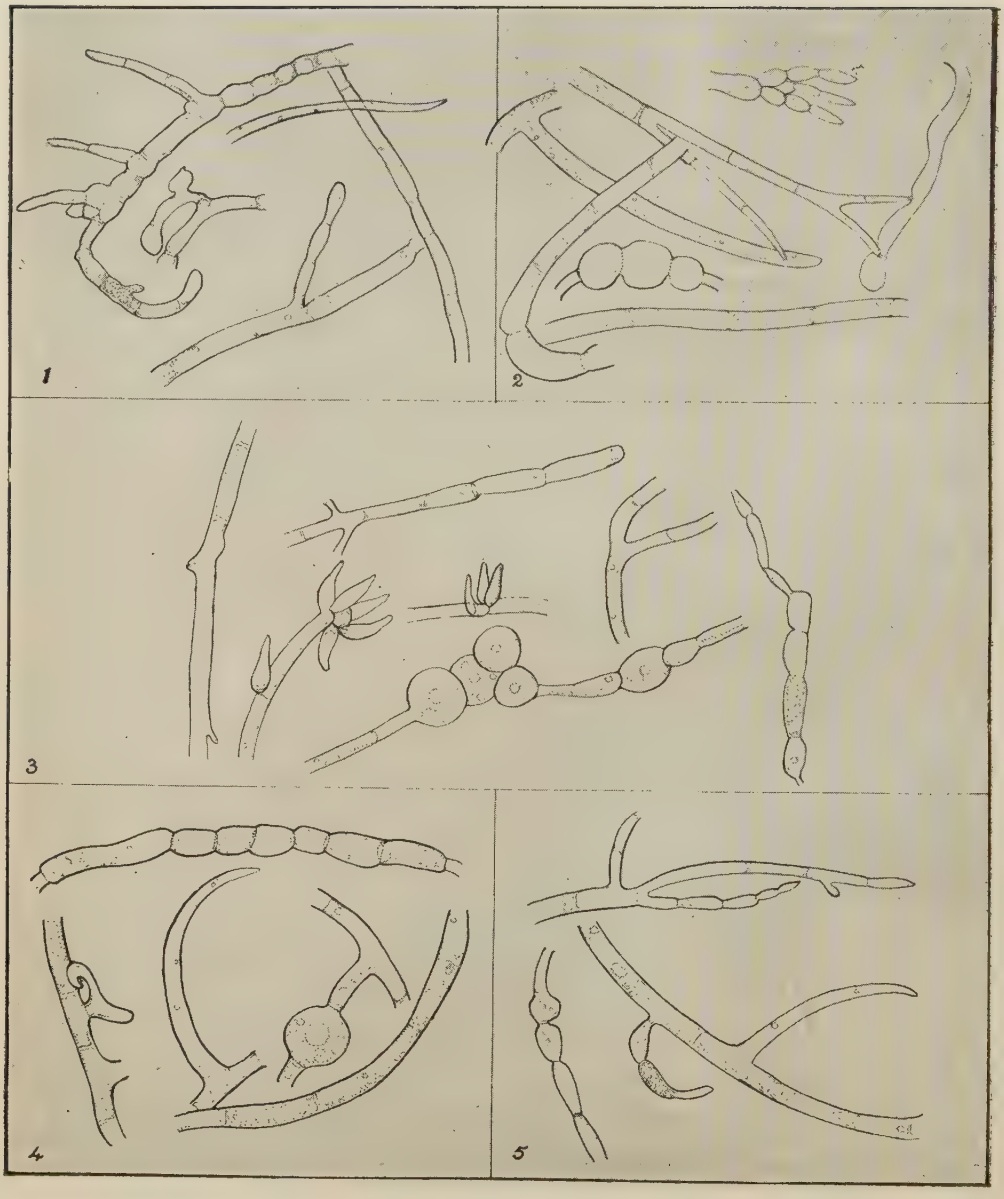


Scale. 1″ to 20 microns.

Camera lucida drawings of spores of the six organisms on potato-dextrose agar, 21 days at 20o C.

1. Colletotrichum tabificum.
2. Saltation.
3. Vermicularia varians.
4. Quebec organism.
5. Colletotrichum atrovirens.
6. Colletotrichum atramentarium.

PLATE II



Scale. 1/10″ to 3 microns.

Camera lucida drawings of mycelium, on corn meal agar, 21 days at 20o C.

1. Colletotrichum tabificum.
2. Saltation.
3. Quebec organism.
4. Cotletotrichum atramentarium.
5. Colletotrichum atrovirens.

Setae were observed to arise from the sclerotia of all the organisms at some time or another. In the case of the *Quebec organism* and *Vermicularia varians* setae were found present in all the cultures while in the case of *Colletotrichum tabicfium*, *Colletotrichum atramentarium* and *Colletotrichum atrovirens* setae were not present at all times and when present were fewer and much shorter. The last two organisms named have been cultured on artificial media for a much longer time than the others and the writer attributed the non appearance of setae to this fact. The setae arising from the sclerotia of the *Quebec organism* and *Vermicularia varians* varied in length from 80 - 120u; the width near the base was from 2–2.6u, and tapered to a fine point. The oldest setae are usually 2–4 septate, black in color and arise from the centre of the sclerotium. When young, they are light colored towards the tip.

Spores of the six organisms were germinated in tap water in hanging drops. Germination was similar in each case. Each spore produced a single germ tube. Germination was typically acroblastic, but in cases where it was pleuroblastic the germ tube originated nearer the apical end.

On Liquid Media.

The organisms under observation grew well on suitable liquid media, but the chracteristics discussed above were, on the whole, very much slower in development, and did not prove as striking in appearance as those displayed on the solid substrata.

On liquid media, the same similarity in type of growth was observed, the *Saltation* being the only one that could be differentiated from the others on any of the media used. It could be picked out by the fact that only white submerged mycelium developed and no sclerotia appeared. There were three main stages in the growth of all cultures; first, the formation of white submerged mycelium, second, the formation of a surface layer of mycelium and third, the appearance of sclerotia on the surface layer. After the formation of the surface layer the pink coloration (described later) was evident before the black sclerotia were formed. No growth resulted in flasks containing Knop's solution, and from this fact it would appear that sugar is essential to growth.

Rate of growth.

The following experimental work was carried on to determine and compare the rate of growth on solid media of the five organisms. *Vermicularia varians* has been omitted from this study as a culture of it was not available at the time the work was done.

The methods adopted were as follows:

1. Petri dishes of uniform size (90 mm. in diameter and 14 mm. in depth) were chosen and sterilized in a hot air oven in the usual manner.

2. Four different solid media were chosen, potato-dextrose agar, Czapek's, cornmeal agar and oatmeal agar. Fifteen cc's of the media were poured into each dish and allowed to solidify.

3. Approximately two weeks before the starting of each series of experiments, cultures of each fungus were started, by transferring small bits of medium containing mycelium from a stock culture to the centre of potato-dextrose agar plates. These plates were used as the source of inoculum for the *experimental* cultures. Little plugs or disks, 5 mm. in diameter and about 2 mm. in thickness were cut by means of a sterile cylindrical tube. Each disk was lifted on the flattened end of a platinum needle and was then inverted and placed centrally upon the surface of a new plate. As the mycelium grew out in every direction from the centre of the plate a rounded mat was formed. The disk remained practically circular as it enlarged, forming nearly a perfect circle at all stages of enlargement.

4. Measurements were made at daily intervals for a culture period of ten days. A thin millimeter rule, applied on the bottom of the petri dish outside, was used for measuring the diameter of the growth. Measurements with the millimeter rule were read to within 1 mm. This was thought to be sufficiently precise for the purpose.

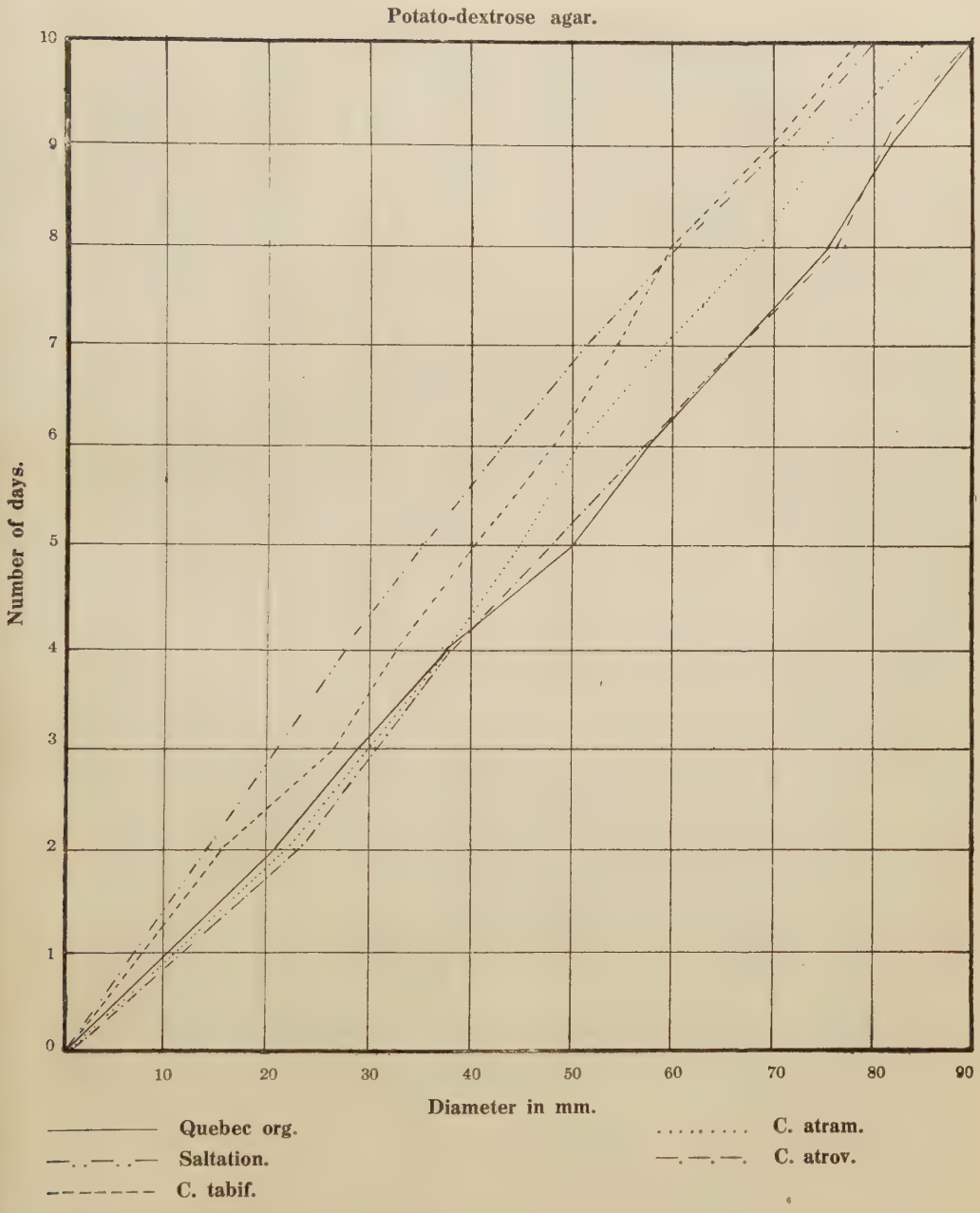
5. All the cultures were grown under exactly the same conditions as to depth of medium, moisture, temperature and light.

6. In any case where the mycelial disk in the petri did not form an exact circle, the diameter was measured in several places and the average taken.

The following table and graph show the results:

Diameter in mm. at the end of 10 days.

Organism.	Potato.	Czapek's.	Cornmeal.	Oatmeal.
Que. org.	88	63	67	72
Saltation.	80	64	60	74
C. tabif.	78	68	70	69
C. atram.	85	67	73	79
C. atrov.	90	73	71	80



The preceding table and graph show that :

1. The rate of growth for the five organisms is very similar.

2. Of the four solid media tried, potato-dextrose agar was the best for growth; oatmeal agar was second while cornmeal and Czapek's were almost equal.

3. There is a marked regularity in rate of growth in each case as indicated by the graph.

The following experiments were conducted with three objects in view :—

1. To determine the proportions to obtain the best growth.
2. To study the type and amount of growth.
3. To ascertain the relationship between growth and H–ion concentration.

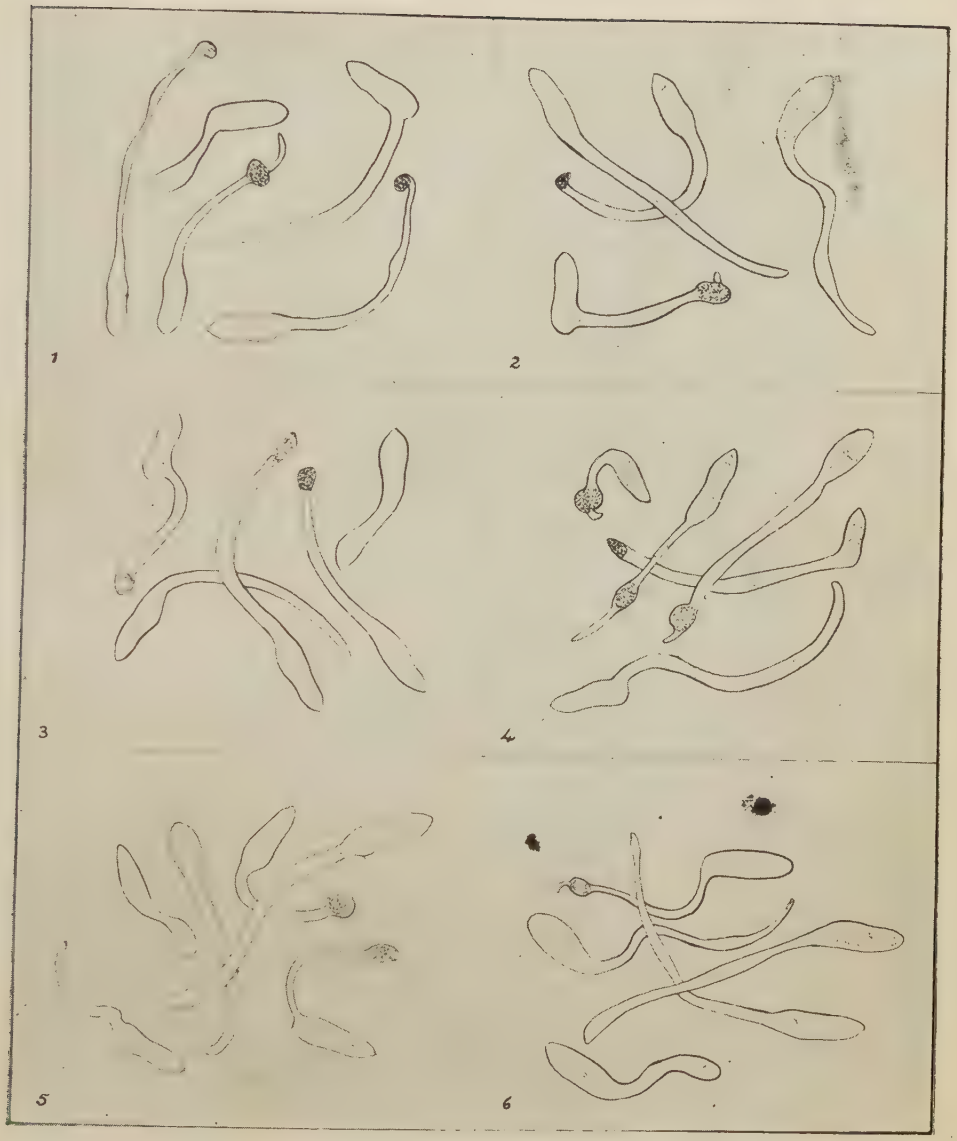
From the previous culture solutions it will be noted that a number of inorganic elements have been used. We have, however, no evidence to the effect that these inorganic elements have been used in the correct proportions. Since the salt requirements for fungi are probably the same as for higher plants, a series of culture solutions was arranged according to the method used by Young and Bennett ('22) in their studies of fungi in culture media. A series of twenty-one cultures, using potassium acid phosphate (monobasic), calcium nitrate, and magnesium sulphate was set up. The salts varied in the different solutions by increments of one-eighth and had an osmotic concentration of three and one-half atmospheres. Sucrose was added in equal amounts of 3.42 grams per 100 cc. of the culture, thereby giving the culture solution a total osmotic concentration of four and one-half atmospheres.

In these triangles the individual cultures are numbered according to the row in which they occur and according to their position in the row. The rows are numbered from the base to the apex of the triangle. The position in the row is from left to right. Thus the culture on the extreme left of the first row is numbered 11, the second from the left in the third row is 32, and in this way every culture flask receives a number.

The method of arranging the concentrations is given in the following table :—

Flask no.	Cc. of M/14 KH_2PO_4	Cc. of M/14 $Ca(NO_3)_2$	Cc. of M/14 $MgSO_4$	Cc. of Sugar sol. 3.42g. in 10cc.	Water to make sol. to 50 cc.
11	4.0	4.0	22.4	5	14.6
12	5.5	6.8	17.2	5	17.5
13	3.4	10.0	13.2	5	18.4
14	3.1	12.4	9.4	5	20.1
15	3.1	15.0	6.0	5	20.9
16	3.0	17.0	2.8	5	22.2
21	7.4	4.0	17.2	5	16.4
22	7.0	6.8	15.2	5	18.0
23	6.5	10.0	9.4	5	19.6
24	6.2	12.4	6.0	5	20.4
25	6.0	15.0	2.8	5	21 2.
31	10.6	4.0	13.2	5	17.2
32	10.0	6.8	9.4	5	18.8
33	9.5	10.0	6.0	5	19.5
34	9.0	12.4	2.8	5	20.8
41	13.8	4.0	9.4	5	17.8
42	13.2	6.8	6.0	5	19.0
43	12.6	10.0	2.8	5	19.6
51	17.2	4.0	6.0	5	17.8
52	16.4	6.8	2.8	5	19.0
61	20.3	4.0	2.8	5	17.9

Special care was taken in the inoculation of solutions so as to obtain uniform growths at the outset. A modification of Hasselbring's ('06) method of



Scale. 1/2″ to 20 microns.

Spores germinating in tap water, 36 hours at room temperature.

1. Colletotrichum tabificum.
2. Saltation.
3. Vermicularia varians.
4. Quebec organism.
5. Colletotrichum atramentarium.
6. Colletotrichum atrovirens.

PLATE IV.

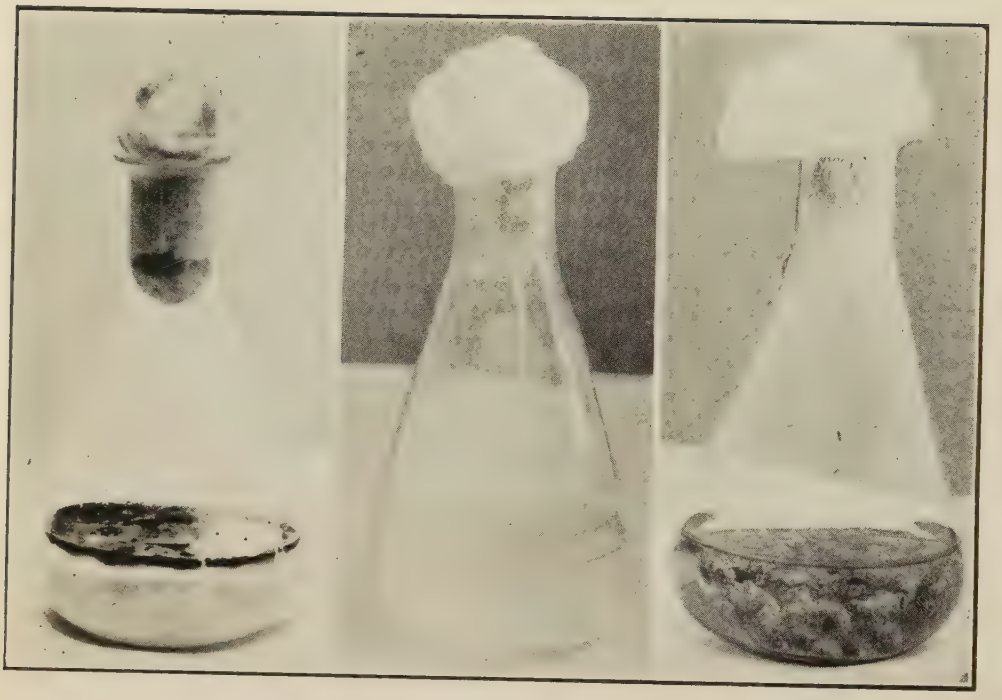


Fig. 1. Fig. 2. Fig. 3.

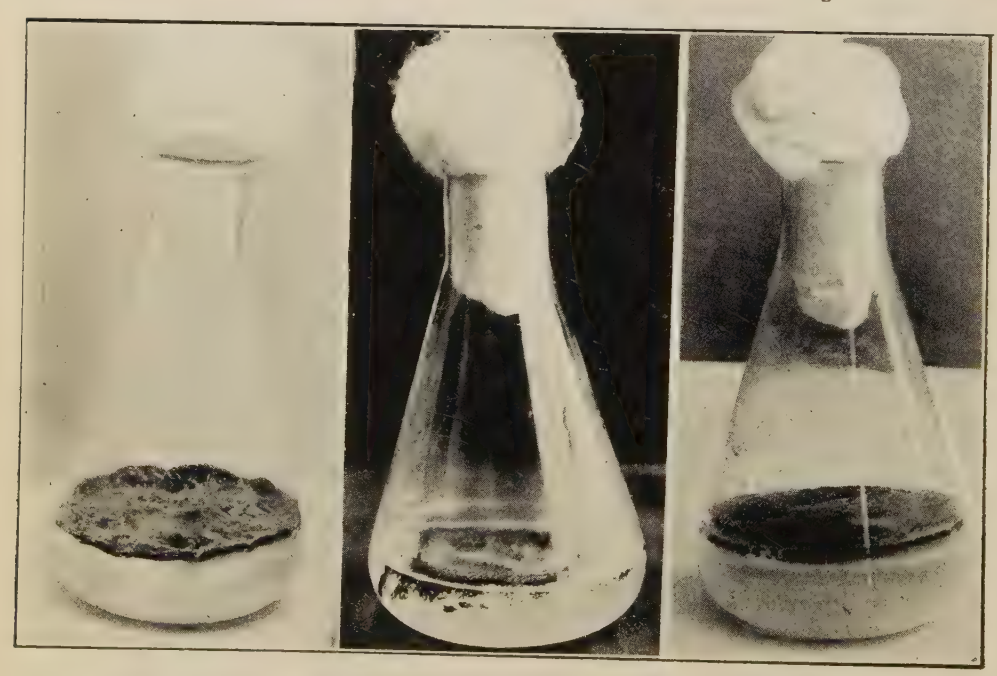


Fig. 4. Fig. 5. Fig. 6.

Growth in flask 61 (apex of triangle) 16 days at 21o C. Solutions composed of :

M,14 KH_2PO_4	—	20.3 c.c.
M,14 Ca (No 3) 2	—	4.0 c.c.
M,14 Mg SO 4	—	2.8 c.c.
Sugar (3.42 g. in 10 c.c.)	—	5.0 c.c.
Water (distilled)	—	17.9 c.c.

Fig. 1—Quebec organism.
Fig. 2—Saltation.
Fig. 3—Vermicularia varians.
Fig. 4—Colletotrichum tabificum.
Fig. 5—Colletotrichum at amentarium.
Fig. 6—Colletotrichum atrovirens.

spore suspension was adopted. A stock culture, on potato-dextrose agar, of the organism to be used (which was well covered with spores) was thoroughly stirred in sterile water in the tube in which it was growing. The stirring was done with a sterile glass rod. The suspension was then poured on a screen of fine-meshed muslin in a funnel, and strained into a sterilized flask. This gave a liquid turbid with spores, most of which had been shaken apart and floated free in the liquid. Very little other material passed into the flask. For inoculation one cc. of this liquid was passed into each flask by means of a sterile pipette. This gave an abundance of spores, which were uniformly distributed in the culture media.

The cultures were allowed to grow for a period of sixteen days in an incubation chamber where the temperature did not vary more than two degrees. The chamber was lighted with electric lights all the time during the period of growth. The yield of dry material produced was used as an indication of the effect of the food supplied. The dry weight of material was obtained by filtering through a filter paper which had previously been weighed. The filter paper containing the mycelium was then placed in a drying oven kept at a constant temperature and left there until thoroughly dried. The filter papers were again weighed and the amo unt of dry weight calculated. All the yields of each series were subjected to the same conditions in drying.

The H–ion concentration of each culture solution was determined before the flasks were inoculated and after the period of growth. The colorimetric method of H–ion determination as described by Clarke and Lubs ('17) and later more fully by Clarke ('21) was used in this phase of the work. From time to time the electrometric method was used to act as a check.

The results of the cultures of the *Quebec organism,* are given in the following table. The results obtained from the other five organisms were very similar to this :

Flask No.	Initial pH.	Final pH.	Dry wt. in gms.	Rank.
11	5.0	5.8	.375	3
12	5.3	5.7	.344	8
13	5.0	5.6	.320	14
14	5.4	5.8	.288	20
15	5.2	5.7	.325	13
16	5.2	5.6	.235	21
21	4.6	5.6	.323	15
22	4.8	5.8	.374	6
23	4.9	5.6	.337	9
24	4.8	5.6	.308	16
25	4.4	5.6	.329	12
31	4.5	5.6	.375	4
32	4.4	5.7	.333	11
33	4.4	5.6	.388	1
34	4.6	5.7	.363	7
41	4.5	5.6	.301	19
42	4.4	5.6	.305	17
43	4.5	5.6	.375	5
51	4.3	5.6	.302	18
52	4.3	5.7	.383	2
61	4.2	5.6	.336	10

Note: These results are the average of two sets of cultures.

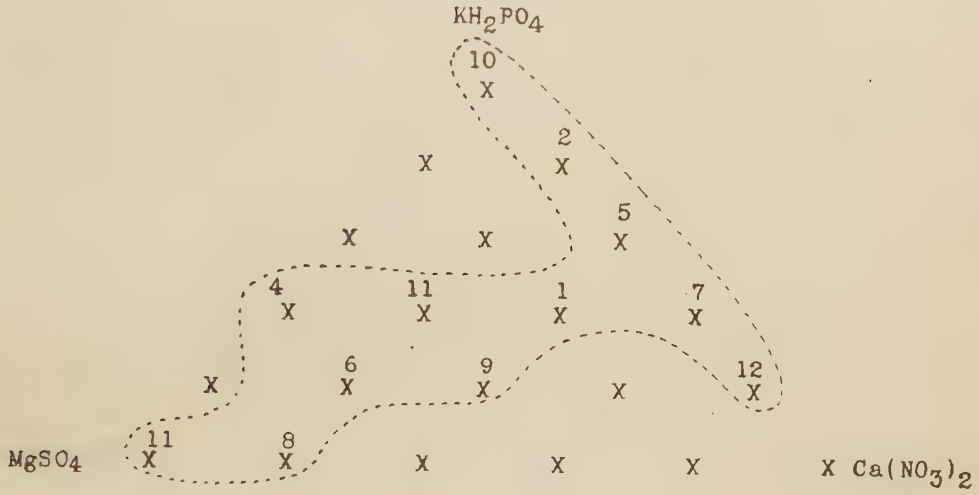
The *Quebec organism* grew well in all the flasks with marked similarity in type. For the first week the culture gave a soft, white submerged mycelial growth and on the ninth day a white surface mat had formed which by the eleventh day was showing a pink coloration on the surface of the mat. This pink coloration, on close examination, was found to be due to large numbers of circular pink bodies, hard in texture, which when crushed under a cover glass discharged large numbers of what appeared to be oil globules. By the sixteenth day this pink coloration had changed to dark brown and in a number of flasks to a distinct black. On examination under the microscope this black growth was found to consist of large masses of coalescing sclerotia. No spores were found in any of the cultures examined. The surface layer at the end of the sixteenth day varied in thickness from 1-16″–1-8″.

Vermicularia varians, C. tabificum, C. atramentarium, and C. atrovirens showed the same growth exactly as that of the *Quebec organism.*

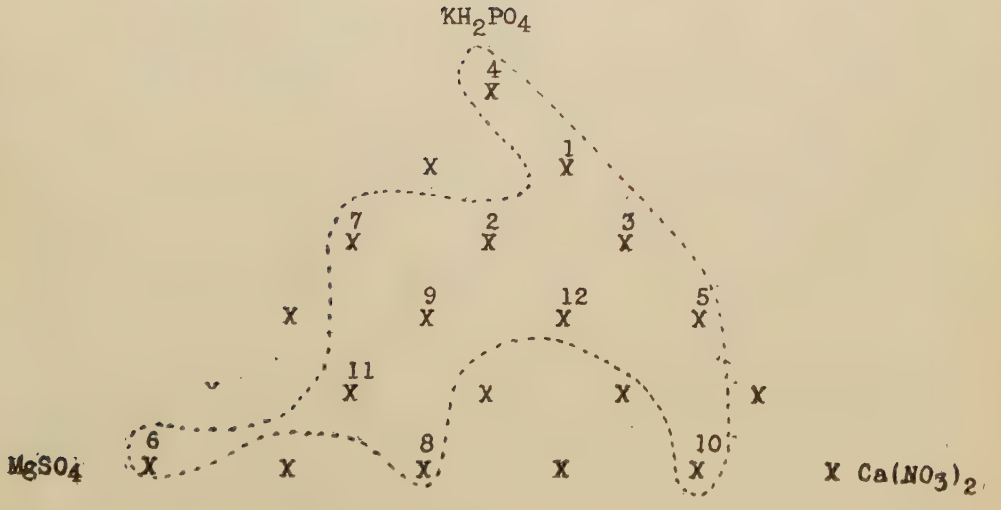
The *Saltation* differed in type of growth from the others in some respects. On the third day small particles of white, downy mycelial growth were visible throughout the liquid. By the twelfth day white submerged growth had become denser while, in some flasks there appeared white horn-like structures protruding from the surface of the liquid. On examination these proved to be dense rope-like masses of mycelium. No pink coloration was noted and no surface mat of mycelium was formed. At the end of the growth period nothing but a submerged mass of white mycelial growth could be seen.

The following diagrams represent the arrangement of the triangular system The area within the dotted lines in each case represents the twelve cultures making the best growth:—

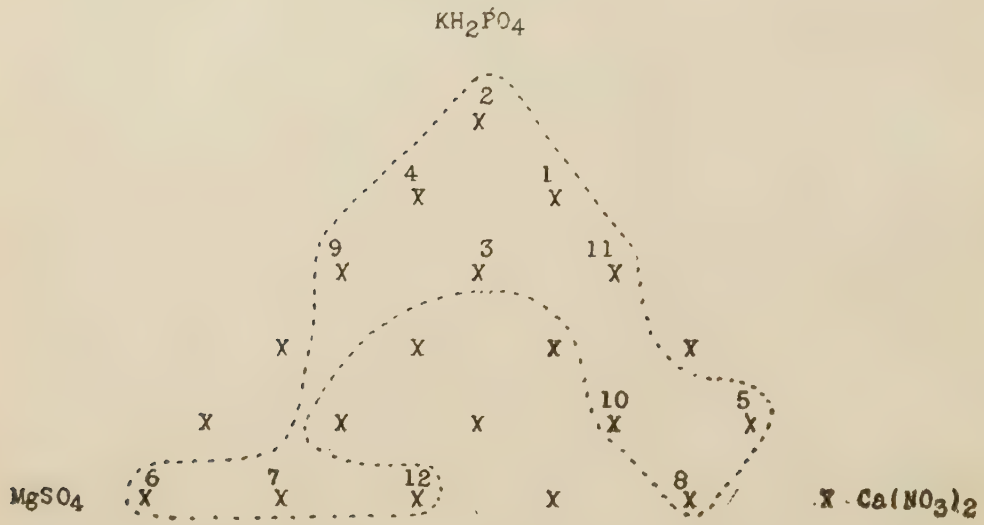
Quebec organism.



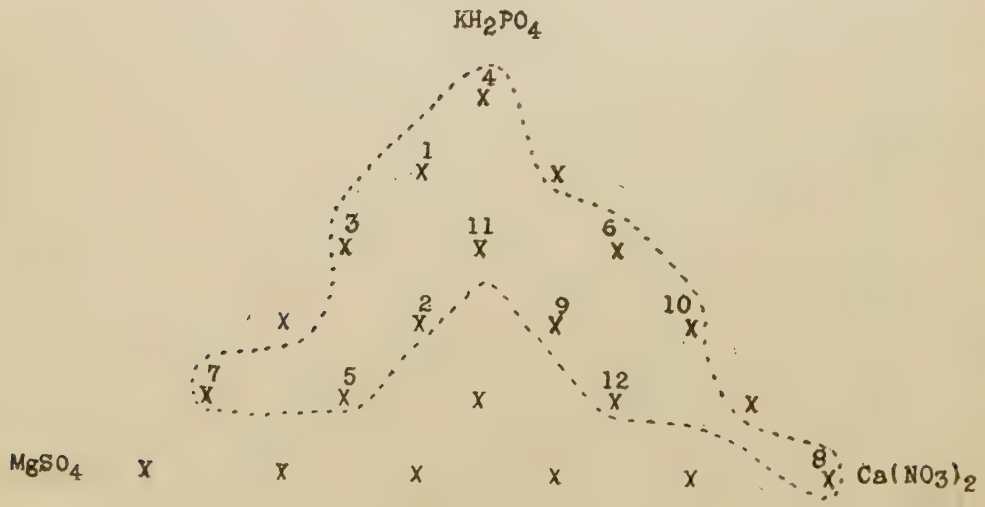
Saltation.



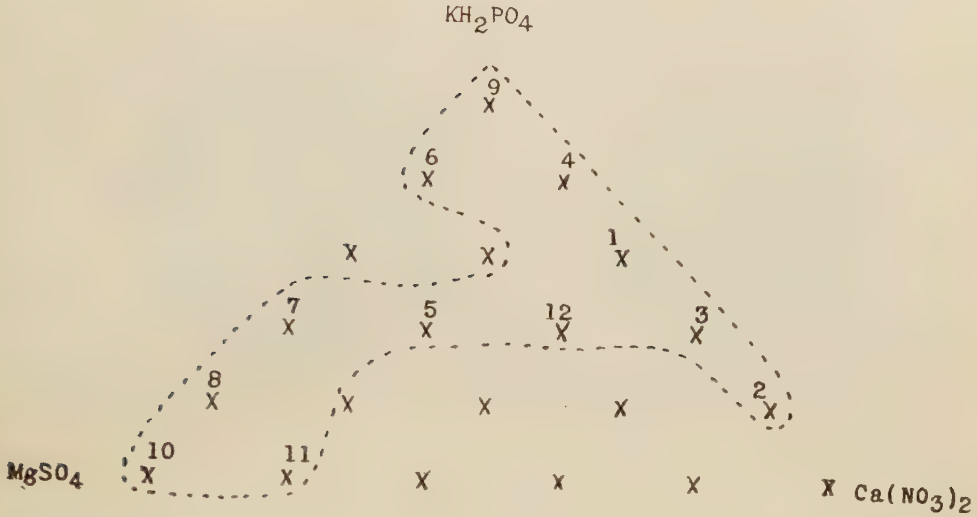
Vermicularia varians.



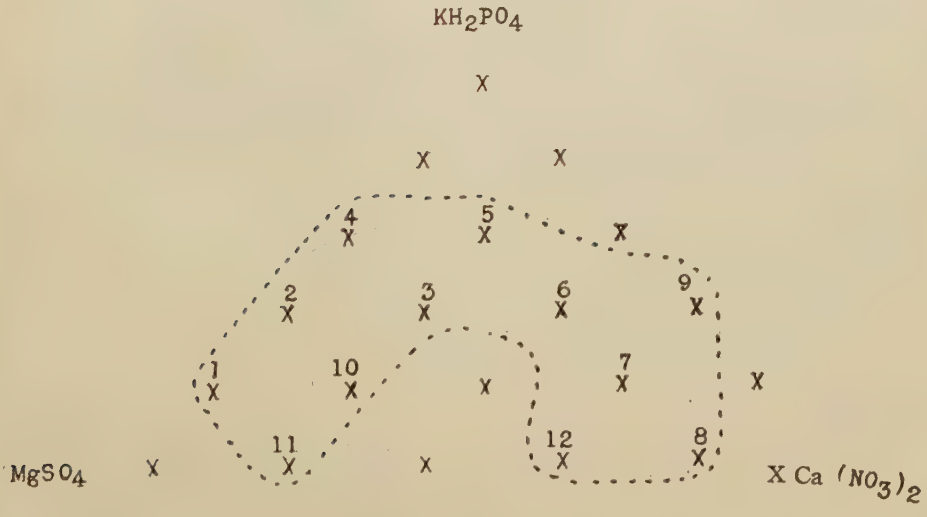
Colletotrichum tabificum.



Colletotrichum atramentarium.



Colletotrichum atrovirans.



From a close study of the preceding table and growth diagrams, the following tentative conclusions may be drawn:

1. The relationship between growth and H–ion concentration for the six organisms was similar, that is, the growth of the fungus for a period of sixteen days caused the solutions in which they grew to become less acid. On the average the change was 1.1., and it is likely that had the cultures been continued for a longer period the change towards alkalinity would have been greater.

2. From the fact that the triangulation diagrams showing best growth are practically the same for all the organisms, it would appear that they are identifical in their nutrient requirements.

3. Since the best growth appears in the flasks nearest the apex of the triangle $KH_2\ PO_4$ may be said to be the limiting factor for growth of the three salts used.

4. With the exception of the *Saltation*, there was a very marked similarity in the type of growth. One organism could not be distinguished from another at any time during the period of culturing.

Effect of light, temperature and carbon dioxide.

As the result of numerous tests it was found that the temperature limits for all the organisms were the same.

Light was found to be responsible for zonation, high color and for a slight retardation in the rate of growth.

Experiments were carried out to ascertain whether the fungi would grow in an atmosphere of carbon dioxide and if so whether any change in the type of growth could be detected. It was found that the organisms growing in the atmosphere of CO_2 were exactly similar to the check cultures in every way. The rate and type of growth were identical.

Summary.

1. Six organisms (*Quebec organism, Saltation, Vermicularia varians, Colletotrichum tabificum, Colletotrichum atramentarium, Colletotrichum atrovirens*) all causing a disease of the potato were used in these experiments. They were grown on certain solid and liquid media.

2. The following points were especially studied:
   (a) Type and rate of growth.
   (b) Salt requirement.
   (c) Hydrogen-ion reaction.
   (d) Morphological and physiological characteristics.
   (e) Effect of temperature, light and carbon dioxide.

Conclusions.

From the results of the above series of studies, the writer feels justified in concluding that the *Quebec organism, Vermicularia varians, Colletotrichum tabificum, Colletotrichum atramentarium* and *Colletotrichum atrovirens* are identical from a morphological and physiological standpoint.

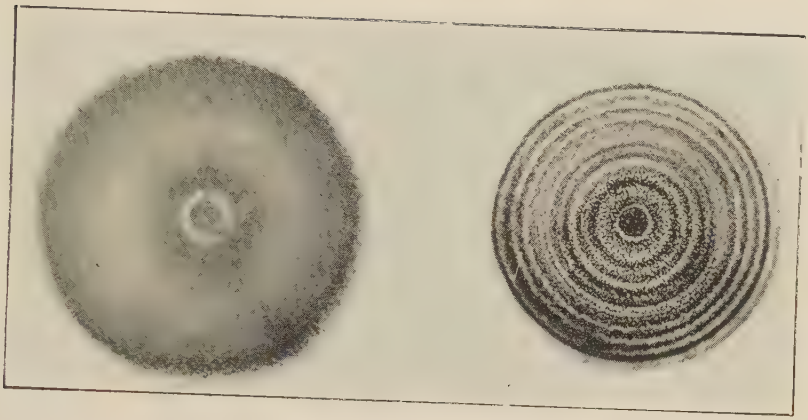


Fig. 1.

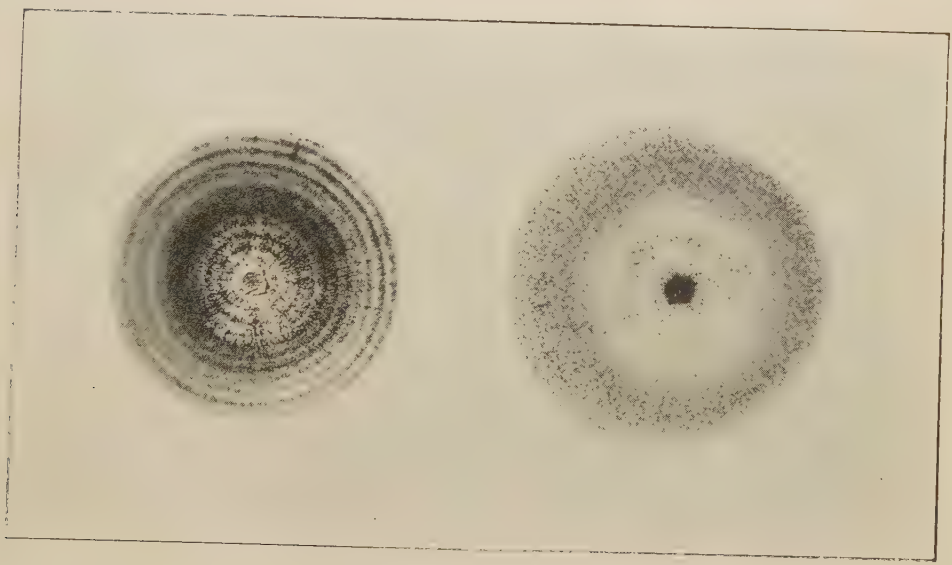


Fig. 2.

Growth in total darkness and in sunlight. Cultures on the left in each figure were grown in darkness, those on the right in sunlight. Note the zonation present to a marked extent, in the cultures grown in sunlight.

Fig. 1—Colletotrichum atramentarium.

Fig. 2—Colletotrichum atrovirens.

The Saltation is similar to the others in every respect, except that no sclerotia develop on artifical media, and, as far as coloration is concerned more yellow than amethyst usually occurs.

This article is an abridgment of a thesis taken under Dr B. T. Dickson in the Department of Botany, Macdonald College, and submitted to the Graduate School of McGill University in partial fulfilment of the requirements for the degree of M. Sc.

In conclusion the writer wishes to express his appreciation to Dr. B. T. Dickson for his valuable advice, and for kindly direction and criticism.

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INDICES TO THE PRELIMINARY LIST OF THE IN SPECTS OF THE PROVINCE OF QUEBEC

(Parts I and II)

Prepared by

Prof. ELIAS ROY, Collège de Lévis,

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ABSTRACTS OF CANADIAN PLANT PATHOLOGICAL LITERATURE.

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Anonymous. Plant Diseases. 47th Ann. Rept. Ont. Agric. Coll. and Exp. Farm for 1921: 34–39. 1922.—Mention is made of late blight of celery, streak of tomatoes, and the dry formal dehyde treatment for oat smut.

Anonymous. Plant Diseases. 48th Ann. Rept. Agric. Coll. and Exp. Farm for 1922: 37–42. 1923.—Notes on pink rot of onions, white rot of grapes, and root rot of field peas.

Bisby, G. R., J. F. Higham, and H. Grob, Potato Seed Treatment Tests in Manitoba. Sci. Agric. 3: 219–221. 1923.—Experiments carried on during a period of three years indicate that at Winnipeg seed treatment with formaldehyde or corrosive sublimate for the control of rhizoctonia is not effective although it reduces the amount of scab. Copper sulphate was not found to be safe or reliable for seed treatment.

Ceasar, L. Some notes on Spray Matters. 15th Ann. Rept.Que. Soc. Prot. Plants for 1922–1923: 28–34. 1923.

Caron, Omer. The Seed Plot as a Measure of Protection. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 45–47. 1923.

Cook, M. T. Past and Future of Plant Pathology. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 14–28. 1923.—An address given before the Quebec Society in which the history of plant pathology up to the present is discussed and the probable lines of development in the future are indicated.

Coulson, J. G. Peony Diseases. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 67–70. Pl. 2–3. 1923.—Seven diseases of the peony are enumerated, the most important of which is the *Septoria* leaf spot.

Dickson, B. T. A study in Disease Susceptibility. Sci. Agric. 3: 307. 1923.

Dickson, B. T. Raspberry Mosaic and Curl. Sci. Agric. 3: 308–310. 1923.—The symptoms and method of dissemination of these important diseases of raspberry are described; methods of control are outlined for each.

Dickson, B. T. A Study in Disease Susceptibility. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 60. Pl. 1. 1923.

Dickson, B. T. Plant Diseases of 1922 in Western Quebec. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 43–45. 1923.

Dickson, B. T., R. Summerby, and J. G. Coulson. Experiments in the Control of Oat Smut. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 102–105. 1923.—Germination of hull-less oats was much reduced by the formaldehyde treatment. Both copper sulphate-lime dust and copper carbonate dust were found to be as effective as the formalde hyde spray in controlling smut.

Drayton, F. L. Survey of the Prevalence of Plant Diseases in the Dominion of Canada, 1922. Canada, Dept. Agric. Exp. Farms Branch: 3rd Ann. Rept. 1–192. 1923.

Duff, G. H. The Occurrence and Frequency of Species of *Ribes* and *Grossularia* in Ontario. Ann. Rept. Min. Lands and Forests, Ont. for 1921–1922: 254-263. 3 fig. 1923.—The report of a survey from Petawawa on the Ottawa river to Georgian Bay undertaken in order to secure definite data on the occurrence of wild *Ribes* and to learn if any ecological relationships existed which might be of value wshould eradication ever become necessary. The results of the investigation showed that *Ribes* are so numerous and occur so generally that a programme of eradication could only be undertaken at a very high cost.

Eastham, J. W. Fungicides. Sci. Agric. 3: 190–191. 1923.—A brief discussion of present methods of combatting plant diseases. No attempt, apparently, has been made to test the efficacy of a large number of various chemicals upon different plant pathogens, most fungicides being modifications of the copper sulphate or lime sulphur groups. Local conditions often require the modification of a formula which is quite satisfactory elsewhere.

Eastham, J. W. Some Potato Disease Problems in British Columbia. Sci. Agric. 4: 89–94. 1923.—An account of the most important potato diseases occurring in British Columbia Leaf roll is not rearly as common as in Eastern Canada but mosaic occurs very frequently.

Eastham, J. W. Report of Provincial Plant Pathologist, Vancouver. 17th Ann. Rept. B. C. Dept. Agric. for 1922: 66–70. 1923.—Wilt of sunflowers caused by *Sclerotinia* sp. and mosaic of red raspberry were noted for the first time. The status of blister rust in British Columbia is described.

Faull, J. H. Forest Pathology: In Report of Forestry Branch, 1922. Ann. Rept. Min. Lands and Forests, Ont. for 1921–1922: 245–254. Fig. 5–9. 1923.—"Red branch" of balsam, pine, and cedar due to injury by *Monahamus* spp. late in the season is described. A preliminary description of five types of butt and heart rots of balsam is given.—A list of balsam rusts occurring in Temagami is appended; this includes two new species described by Bell.

Fraser, W. P., and P. M. Simmonds. Co-operative Experiments with Copper Carbonate Dust and Other Substances for Smut Control. Sci. Agric. 3: 297–302. 1923.—The results of extensive experiments upon control of smut indicate that copper carbonate is the most effective of a number of dusts tested for this purpose. With heavily infected seed the formaldahyde treatment gives better results and so, while dusting has certain advantages, it is not recommended that it be substituted for this form of treatment until it has been further investigated.

Gussow, H. T. Interim Report of the Dominion Botanist. Canada, Dept. Agric. Exp. Farms Branch for 1921-1922: 1–73. 3 fig. 1922.—The usual annual report of the work carried on by the Division of Botany. Attention is drawn to the sections dealing with forest pathology, potato inspection, leaf curl and mosaic of raspberries, and cereal rusts.

Gussow, H. T. Report of the Dominion Botanist. Canada, Dept. Agric. Exp. Farms Branch for 1922–1923; 1–74. Fig. 1–10. 1923.—The annual report of the Division of Botany containing accounts of the various phases of investigative work carried on at the central and field laboratories.

Hind, H. Y. Essay on the Insects and Diseases injurious to the wheat Crops. 1–139. Toronto. 1857.—In 1856 the Bureau of Agriculture and Statistics of the Government of Upper Canada offered three prizes of L40, L25 and L15 for the three best essays, respectively, on the "Origin, nature, and habits.—and the history of the progress, from time to time,—and the cause of the progress, of the weevil, Hessian fly, midge, and such other insects as have made ravages on the wheat crops in Canada; and on such diseases as the wheat crops have been subjected to, and on the best means of evading or guarding against them". This essay, by the professor of chemistry at Trinity College, Toronto, won the first prize.

At that time entomology was apparently more highly developed than plant pathology since, of a total of seven chapters six are devoted to the consideration of injurious insects. In the chapter on wheat diseases rust, smut, and ergot are dealt with and the writer has many quaint misconceptions in regard to the nature of these fungi. Thus, "Rust is the growth of two kinds of fungi. uredo rubigo and uredo linearis". It is interesting to note that the author suspects that the rust spores gain entrance to the wheat plant by way of the stomata.

As for control it is recommanded that powdered charcoal be distributed over the wheatfields in order to absorb the atmosphoric ammonia, which it is believed, favours the development of rust by "stimulating the growth of the sporules in the stagnated juices of the plants." In addition, early sowing and 'the selection of flinty-stemmed varieties whose stomata on the stalk will have in great part closed before the "time for rust" are advised.

Hockey, J. F. Blue Stem of Black Raspberry. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 92–93. 1923.—This disease is reported for the first time from the Niagara Peninsula. A fungus closely resembling *Acrostalagmus caulophagus* Lawrence was isolated from diseased canes

Howitt, J. E. Two Diseases New to Ontario. Sci. Agric. 3: 189. 1923.— Pink root of onions (*Fusarium malli* Taub.) and white rot of grapes (*Coniothyrium diplodiella*) (Speg.) (Sacc.) were observed for the first time in south-western Ontario.

Kelsall, A. Experiments on the Dust Method of Smut control. Sci. Agric. 3: 303–307. 1923.—These experiments show that the dusting method of treatment for smut does not give per-

fect control though further work may yield better results. Where seed treatment is not at present practised and where absolute control is not a necessity this form of treatment might be used with advantage.

Lochhead, W. The Protection of Plants. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 11–14. 1923.—The presidential address delivered before the fifteenth annual meeting.

Major, T. G. Cultural Characteristics of Certain Species of Fusarium. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 79–87. 1923.—Several species of *Fusarium* were studied in pure culture to determine the effects of temperature, H-ion concentration, and various media upon the growth characteristics. Wide variations in cultural features were obtained upon different media; the effects of temperature and H-ion concentration were not so pronounced.

McCallum, A. W. Abstracts of Canadian Plant Pathological Literature. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922-1923: 127–129. 1923.

Rankin, W. H. and W. P. Fraser. Survey of the Prevalence of Common Plant Diseases in the Dominion of Canada, 1920. Canada, Dept. Agric. Exp. Farms Branch: 1st Ann. Rept. 1–55. 1921.—This report is the result of the first organized effort made in Canada to collect and publish information in regard to the occurrence and distribution of plant diseases. Reports from every province are included.

Rankin. W. H. and W. P. Fraser. Survey of the Prevalence of Common Plant Diseases in the Dominion of Canada, 1921. Canada, Dept. Agric. Exp. Farms Branch: 2nd Ann. Rept. 1–62. 1922.

Richardson, J. K. A Study of Soft Rot of Iris. 15th Ann. Rept. Que. Soc. Prot. Plants for 1922–1923: 105–120. Pl. 5–7. 1923.—Rhizome rot is becoming an important disease of Iris. Two organisms which on inoculation produced typical rot were isolated from diseased plants; these are believed to be forms or *Bacillus carotovorus*.

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